5440A

Direct Voltage Calibrator

Operator Manual

P/N 608562
MARCH 1983

FLUKE®

WARRANTY

Notwithstanding any provision of any agreement the following warranty is exclusive:

The JOHN FLUKE MFG. CO , INC., warrants each instrument it manufactures to be free from defects in material and workmanship under normal use and service for the period of 1 year from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, disposable batteries (rechargeable type batteries are warranted for 90 days), or any product or parts which have been subject to misuse, neglect, accident, or abnormal conditions of operations.

In the event of failure of a product covered by this warranty, John Fluke Mfg. Co , Inc , will repair and calibrate an instrument returned to an authorized Service Facility within 1 year of the original purchase; provided the warrantor's examination discloses to its satisfaction that the product was defective. The warrantor may, at its option, replace the product in lieu of repair. With regard to any instrument returned within 1 year of the original purchase, said repairs or replacement will be made without charge. If the failure has been caused by misuse, neglect, accident, or abnormal conditions of operations, repairs will be billed at a nominal cost. In such case, an estimate will be submitted before work is started, if requested.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS, OR ADEQUACY FOR ANY PARTICULAR PURPOSE OR USE. JOHN FLUKE MFG. CO , INC , SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT, TORT, OR OTHERWISE.

If any failure occurs, the following steps should be taken:

1. Notify the JOHN FLUKE MFG. CO., INC., or nearest Service facility, giving full details of the difficulty, and include the model number, type number, and serial number. On receipt of this information, service data, or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the instrument, transportation prepaid. Repairs will be made at the Service Facility and the instrument returned, transportation prepaid.

SHIPPING TO MANUFACTURER FOR REPAIR OR ADJUSTMENT

All shipments of JOHN FLUKE MFG. CO., INC , instruments should be made via United Parcel Service or "Best Way"* prepaid. The instrument should be shipped in the original packing carton, or if it is not available, use any suitable container that is rigid and of adequate size. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL PURCHASER

The instrument should be thoroughly inspected immediately upon original delivery to purchaser. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument is damaged in any way, a claim should be filed with the carrier immediately. (To obtain a quotation to repair shipment damage, contact the nearest Fluke Technical Center.) Final claim and negotiations with the carrier must be completed by the customer.

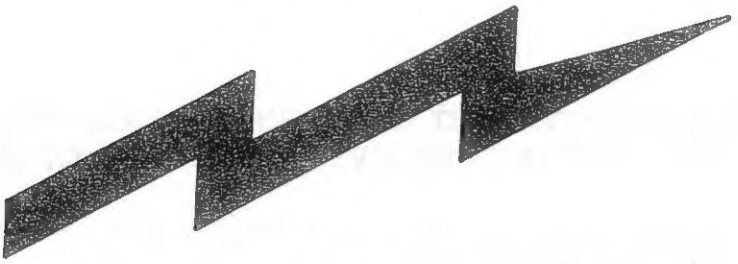
The JOHN FLUKE MFG. CO., INC. will be happy to answer all applications or use questions, which will enhance your use of this instrument. Please address your requests or correspondence to: JOHN FLUKE MFG. CO., INC., P.O. BOX C9090, EVERETT, WASHINGTON 98206, ATTN: Sales Dept. For European Customers: Fluke (Holland) B.V., P.O. Box 5053, 5004 EB, Tilburg, The Netherlands.

*For European customers, Air Freight prepaid.

John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, Washington 98206

Rev. 6/81

WARNING



HIGH VOLTAGE

is used in the operation of this equipment

DEATH ON CONTACT

may result if personnel fail to observe safety precautions

TO AVOID ELECTRICAL SHOCK HAZARD, THE OPERATOR SHOULD NOT ELECTRICALLY CONTACT THE OUTPUT HI OR SENSE HI TERMINALS OF THE INSTRUMENT. DURING NORMAL OPERATION OR SYSTEM SELF TEST, LETHAL VOLTAGES OF UP TO 1100V DC MAY BE PRESENT ON THESE TERMINALS. IN THE EVENT OF MULTIPLE INSTRUMENT FAILURES, LETHAL VOLTAGES OF UP TO 1400V DC MAY BE PRESENT ON THESE TERMINALS.

Never work on the instrument unless there is another person nearby who is familiar with the operation and hazards of the equipment and who is competent in administering first aid. When the technician is aided by operators, he must warn them about dangerous areas.

Whenever possible, the power supply to the equipment must be shut off before beginning work on the equipment. Take particular care to ground every capacitor likely to hold a dangerous potential. When working inside the equipment, after the power has been turned off, always ground every part before touching it.

Be careful not to contact high-voltage connections for the line power ac input connections when installing or operating this equipment.

Whenever the nature of the operation permits, keep one hand away from the equipment to reduce the hazard of current flowing through vital organs of the body.

FIRST AID FOR ELECTRIC SHOCK

RESCUE

FREE VICTIM FROM CONTACT WITH LIVE CONDUCTOR QUICKLY. AVOID CONTACT WITH EITHER LIVE CONDUCTOR OR VICTIM'S BODY.

Shut off high voltage at once and ground circuit. If high voltage cannot be turned off quickly, ground circuit.

An ax with a dry wooden handle may be used to cut high voltage line. Use extreme caution to avoid resulting electric flash.

If circuit cannot be broken or grounded, use a dry board, dry clothing, or other nonconductor to free victim.

SYMPTOMS

NEVER ACCEPT ORDINARY AND GENERAL TESTS FOR DEATH.

Symptoms of electric shock may include unconsciousness, failure to breathe, absence of pulse, pallor, and stiffness, as well as severe burns. WHENEVER VICTIM IS NOT BREATHING PROPERLY, GIVE ARTIFICIAL RESPIRATION.

TREATMENT

START ARTIFICIAL RESPIRATION IMMEDIATELY.

Perform artificial respiration at scene of accident, unless victim's or operator's life is endangered. IN THIS CASE ONLY, remove victim to safe location nearby. If new location is more than a few feet away, give artificial respiration while victim is being moved.

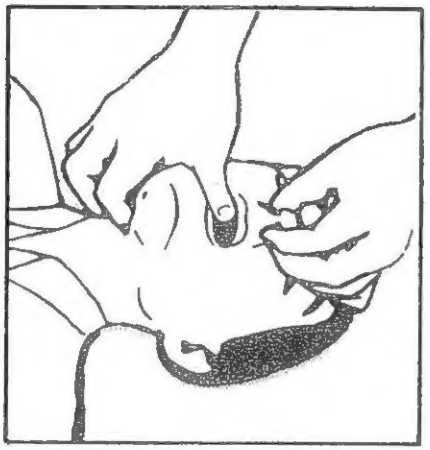
After starting artificial respiration, continue without loss of rhythm for at least FOUR HOURS, or until victim is breathing without help. If you have to change operators while giving artificial respiration, do so without losing rhythm of respiration.

AFTER VICTIM REVIVES

Be prepared to resume artificial respiration, as he may stop breathing again.

When victim is COMPLETELY CONSCIOUS, give him a stimulant (NOT AN ALCOHOLIC DRINK) such as a teaspoonful of aromatic spirits of ammonia in a small glass of water, hot coffee, or hot tea.

Keep victim warm and lying down until he has been conscious for at least fifteen minutes



POSITION VICTIM

Place victim in face-upward position and kneel close to his ear.

CLEAR THROAT

Turn head to one side and quickly wipe out any fluid, mucus, or foreign body from mouth and throat with fingers.

OPEN AIR PASSAGE

Tilt head back and extend neck to open air passage.

LIFT JAW FORWARD

Place thumb in victim's mouth and grasp jaw firmly. Lift jaw forward to pull tongue out of air passage. Do not attempt to hold or depress tongue.

PINCH NOSTRILS CLOSED

With other hand pinch nostrils closed to prevent air leak.

FORM TIGHT SEAL WITH LIPS

Rescuer's wide-open mouth completely surrounds and seals open mouth of victim. This is not a kissing or puckered position — mouth of rescuer must be wide-open.

BLOW

Exhale firmly into victim's mouth until chest is seen to lift. This can be seen by rescuer without difficulty.

REMOVE MOUTH AND INHALE

During this time, rescuer can hear and feel escape for air from lungs. Readjust position if air does not flow freely in and out of victim's lungs.

Continue at a rate of 12 to 20 times per minute.

Breathing should be normal in rate with only moderate increase in volume, so that rescue breathing can be continued for long periods without fatigue. Do not breathe too forcibly or too large a volume if victim is an infant or small child.

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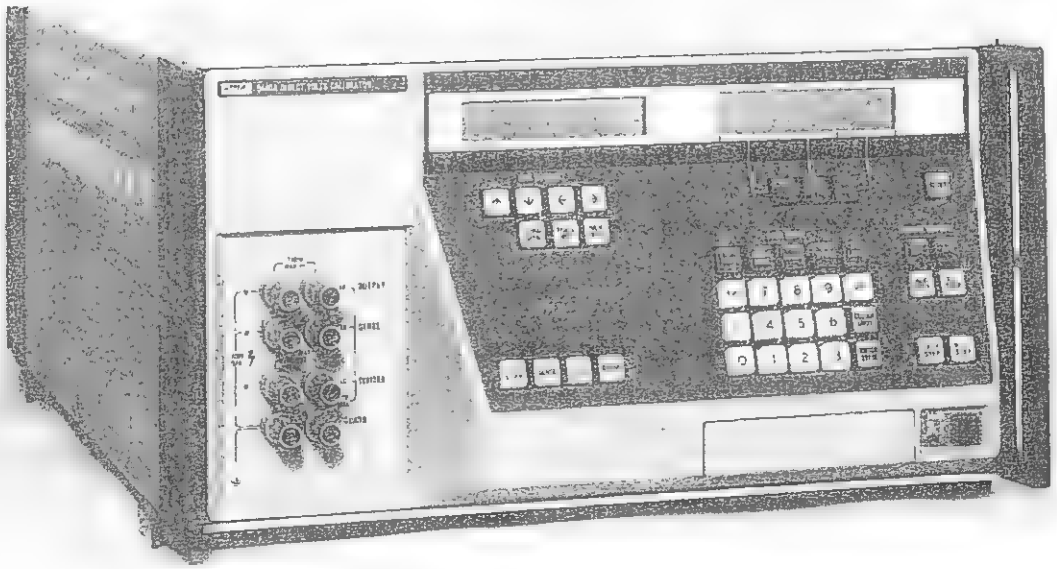


5440A Direct Voltage Calibrator

Section 1
Introduction And Specifications

1-1. THE MANUAL SET

1-2. The John Fluke 5440A Direct Voltage Calibrator is documented by an operator manual and a service manual. The operator manual contains all the information necessary to install and operate the 5440A. The service manual contains the theory of operation, maintenance information, a parts list, and schematic diagrams.

1-3. THE CALIBRATOR

1-4. The John Fluke Model 5440A is a 4 ppm programmable direct voltage calibrator designed for use in production environments as well as the calibration laboratory. The 5440A can be operated manually from the front panel or automatically by a controller via the IEEE-488 interface. Among other features the 5440A:

- Maintains state-of-the-art dc voltage accuracies in a production environment as well as in a calibration laboratory environment.
- Is completely programmable via the IEEE-488 interface
- Has three types of outputs:

  1. Voltage calibrator output (available at the output terminals) with a programmable range from −1100 to +1100V dc.

  2. Boost output (available at the rear panel Boost Interface connector) that drives either Fluke 5205A Precision Power Amplifier a Fluke 5220A Transconductance Amplifier.

  3. Divider output from −2.2 to +2.2V dc (available at the divider terminals).

- Completely controls the output of instruments connected to the Boost Interface.
- Allows the operator to set a reference voltage, limits, current trip point, tolerance floor, percentage of reference error.
- Records user-programmed test sequences in plug-in memory modules.
- Has an automatic internal calibration feature that corrects for drift in internal zero offsets and resistor ratios.
- Directs the user through a semi-automatic external calibration procedure that corrects for long term reference drift.
- Features direct keyboard entry of output settings as well as convenient controls for incrementing and decrementing the output.
- Has rear panel output terminals for easy system connection.
- Automatic monitoring of output voltage and current levels.

1-5. ACCESSORIES

1-6. The accessories available for use with the 5440A are listed in the data sheet inserted at the end of this section. These accessories are described in the Accessories section.

1-7. SPECIFICATIONS

1-8. The 5440A specifications are contained in the data sheet inserted at the end of this section.

Section 2
Installation and Operating Notes

2-1. INTRODUCTION

2-2. The information in this section provides the user with background information necessary to properly install and operate the 5440A. This information should be thoroughly read and understood before attempting to operate the instrument.

2-3. SHIPPING INFORMATION

2-4. The 5440A is packaged and shipped in a foam packed container. Upon receipt of the instrument, a thorough inspection should be made to reveal any possible shipping damage. Special instructions for inspection and claims are included on the shipping container.

2-5. If reshipment of the instrument is necessary, the original container should be used. If the original container is not available, a new container can be obtained from the John Fluke Mfg. Co., Inc., P.O. Box C9090; Everett, Washington 98206; Telephone (206) 347-6100. Please include instrument model and serial number in such correspondence.

2-6. SERVICE INFORMATION

2-7. Each John Fluke Model 5440A Direct Voltage Calibrator is warranted for a period of one year upon delivery to the original purchaser. The WARRANTY is located at the front of this manual.

2-8. Factory authorized service (including calibration) for the 5440A is available at selected John Fluke Technical Service Centers. For service and or calibration, return your instrument to the nearest John Fluke Technical Service Center. The local technical service center will handle transportation to and from the selected technical service centers as required. All John Fluke Technical Service Centers are listed in the Sales and Service Centers section. If requested we will provide an estimate before work is begun on instruments that are beyond the warranty period

2-9. In addition to having the 5440A serviced at a Fluke Service Center, the user may be able to repair the 5440A using the material in the Troubleshooting section of the Service Manual and the Module Exchange Program. The Module Exchange Program is currently limited to the continental United States. The brochure A Module Exchange Program, located in the Application Information section, describes the program.

2-10. 5440A FEATURES

2-11. Figure 2-1 shows all 5440A front panel features. Table 2-1 lists and briefly describes the front panel features. Figure 2-2 shows all 5440A rear panel features. Table 2-2 lists and briefly describes these features.

2-12. INSTALLATION

2-13. Introduction

2-14. The following paragraphs contain the information necessary to prepare the 5440A for operation. This information includes procedures for mounting the 5440A in an equipment rack, connecting line power and connecting the instrument to the IEEE-488 and RS-232-C interfaces.

2-15. Rack Mounting

2-16. The 5440A is designed to be either placed directly on the work bench or to be mounted in standard 24-inch deep equipment rack.

2-17. Input Power

WARNING

TO AVOID SHOCK HAZARD OR INSTRUMENT DAMAGE, CONNECT THE INSTRUMENT LINE POWER GROUND TO EARTH GROUND. DO NOT BREAK THIS GROUND CONNECTION BY USING A TWO CONDUCTOR EXTENSION CORD.

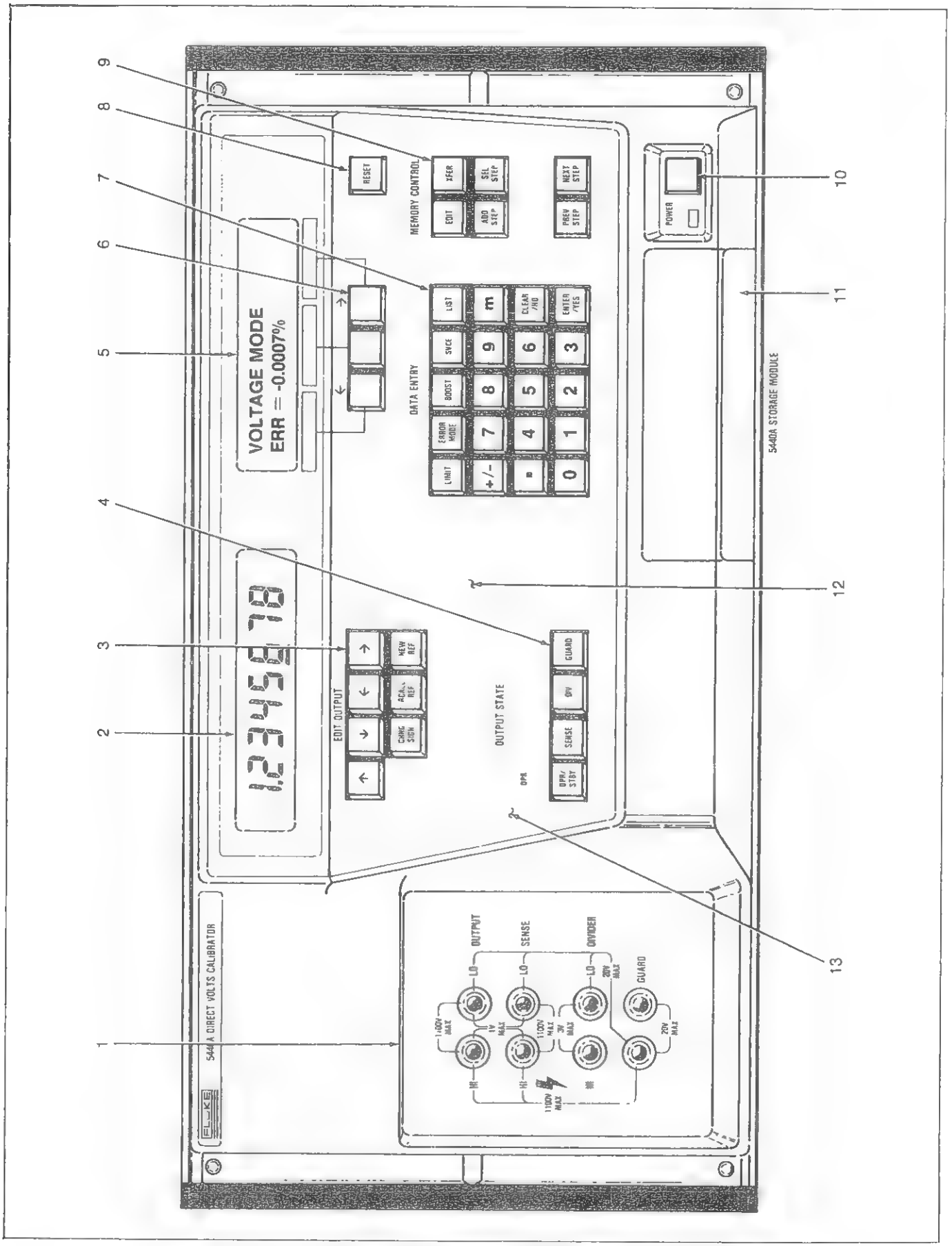


Figure 2-1. Front Panel Features

Table 2-1. Front Panel Features

REF NO.	NAME	FUNCTION
1	Output Terminals	Front Panel binding post connectors.
	OUTPUT Terminals	The output of the 5440A is available at these terminals when the instrument is in Operate and the divider circuit is not enabled.
	SENSE Terminals	External sensing terminals, normally disconnected internally unless external sensing is enabled.
	DIVIDER Terminals	Divided output (below 2.2V dc) is available at these terminals when the 5440A is in operate and the divider output is enabled (OPER and DIV indicators lit).
	GUARD Terminal	Connection to the internal guard chassis.
	GROUND Terminal	Connection for earth ground.
2	Output Display	Eight-digit LCD display of the 5440A output. The annunciators are: V, mV, A, mA and a leading + or −. A cursor (underline) indicates the selected digit during local control
3	EDIT OUTPUT keys	Four keys that are used to edit the Output Display
	← →	Move cursor left or right
	↑ ↓	Increments or decrements the output digit indicated by the cursor. Press and hold to repeat the functions.
	CHGN SIGN	Press to change the polarity of the output.
	RCALL REF	Press to set the output value to the stored error mode reference value.
	NEW REF	Press to store the present output value as the new error mode reference.
4	OUTPUT STATE Keys	Four keys that enable or disable output features. Indicators above each key show when that feature is selected.
	OPR/STBY	Applies the 5440A output to or removes the 5440A output from the OUTPUT or DIVIDER terminals if the Voltage Mode is selected.
	SENSE	Selects internal or external (indicator lit) sensing. In external sensing, the SENSE terminals are connected to the internal sense circuit
	DIV	Connects the 5440A output to the DIVIDER OUTPUT terminals if the selected output is 0 or 2.2 volts and if the 5440A is in Operate.
	GUARD	Connects or disconnects the GUARD terminal from its normal connection to OUTPUT LOW to allow for an external connection.
5	Alpha-numeric Display	A dot matrix display formatted as two lines of twenty characters each. The display is used to present the following four types of messages: 1) Error Display: Indicates an error has occurred and gives instructions to remedy the error 2) Activity in progress: Displays the main activity on the top line and the substep in progress on the bottom line

Table 2-1. Front Panel Features (cont)

REF NO.	NAME	FUNCTION
		3) Digit Entry Prompt: Displays the present data value and prompts the operator to enter numeric values. 4) Soft Key Labels: The 5440A has soft key function. The labels describing the functions appear in the Alphanumeric Display. A soft key function is selected by pressing the unlabeled key under the desired soft key label.
6	Soft Keys	Three unlabeled keys that have two functions determined by the 5440A software: 1) When one of the soft key menus is selected, these keys select the function that appears directly over that key on the Alphanumeric Display. 2) When any display other than a soft key menus appears on the Alphanumeric Display, the right and left arrow keys move the Alphanumeric Display cursor in the corresponding direction
7	DATA ENTRY Keys	A 20-key panel The top row of 5 keys select soft key alternatives (see the Operating Notes in this section). The other 15 keys form a data entry keyboard
8	RESET Key	Key that returns the 5440A to the power-on reset state. This key functions during local and remote operation.
9	MEMORY CONTROL Keys	Six keys that control stored procedures. EDIT and XFER select soft key alternatives. The other four keys add steps to the stored procedures, select a specific step in a stored procedure, or move to the next or previous step
10	POWER Key and Indicator	A key that applies or removes 5440A power The indicator is lit when power is applied
11	5440A-7001 Storage Module Receptacle	Data terminal connector for the 5440A-7001 Storage Module
12	FAULT Indicator	LED that provides independent indication that the 5440A is not operational
13	REAR Indicator	LED that indicates that the 5440A has been configured for rear output operation

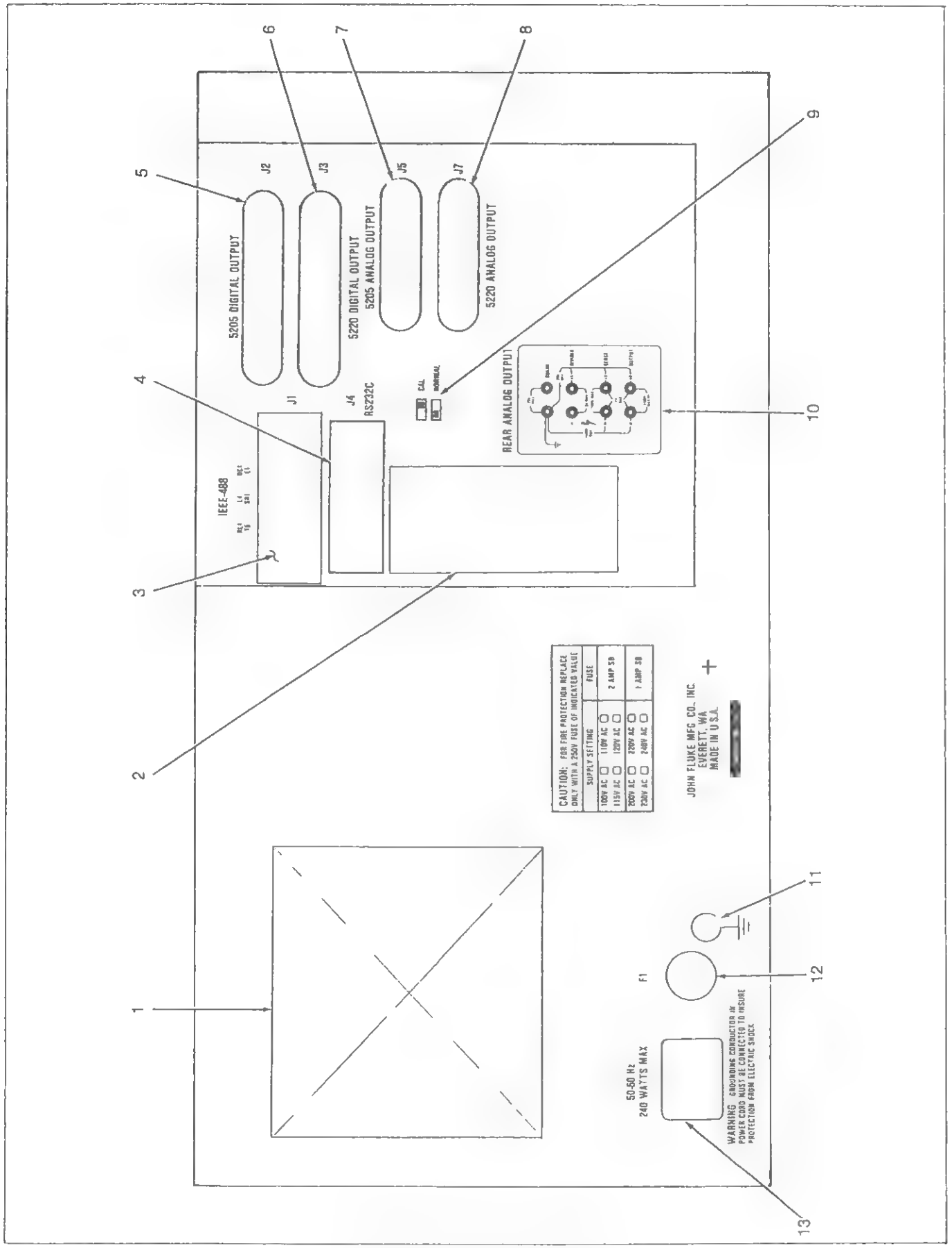


Figure 2-2. Rear Panel Features

Table 2-2. Rear Panel Features

REF NO.	NAME	FUNCTION
1	Filter and Fan	A ventilation fan and filter that provide clean ventilating air.
2	RS-232-C Jumper Plug	A jumper plug, electrically placed between the RS-232-C connector and the RS-232-C circuit inside of the 5440A. This plug allows the RS-232-C input lines to be easily reconfigured. This plug is covered by a protective housing.
3	IEEE-488 Connector (J1)	Standard IEEE-488 interface connector.
4	RS-232-C Connector (J4)	Female RS-232-C interface connector with a covered housing.
5	5205 Digital Connector (J2)	Precision power amplifier digital cable connector for Boost Voltage operation.
6	5220A Digital Connector (J3)	Transconductance amplifier digital cable connector for Boost Current operation.
7	5205 Analog Connector (J5)	Precision power amplifier analog cable connector for Boost Voltage operation.
8	5220A Analog Connector (J7)	Connector for the transconductance amplifier analog cable for Boost Current operation.
9	CAL/NORMAL Switch	Two position switch that enables or locks out the external calibration capability of the 5440A.
10	Rear Output Connector (J6)	Same function as the front panel OUTPUT terminals.
11	Earth Ground Terminal	Connection to the chassis which should be connected to earth ground through the power cord.
12	Line Power Fuse	Input power fuse. 110 to 120V ac - MDX 2A 200 to 240V ac - MDX 1A
13	Line Power Connector	Connector for ac line power.

2-18. The 5440A can be configured to operate on eight line power voltage ranges from 50 to 60 Hz. The 5440A is configured for operation in one of the line voltage ranges by setting the Line-Voltage-Select switches located in the 5440A. The procedure for selecting any of the line voltage configurations is located in the 5440A Service Manual. This procedure must be performed by qualified personnel. Be sure that the 5440A is configured for the correct line voltage range and that the correct value fuse is installed before connecting line power to the 5440A. The line voltage configuration selected at the factory is marked on the rear panel decal.

2-19. Line Power Fuse Replacement Procedure

2-20. Complete the following procedure to replace the line power fuse:

1. Press the POWER key so the the POWER indicator is off and disconnect the 5440A from line power.

2. Using a coin or screwdriver blade, turn the line power fuse holder counter-clockwise.

3. Remove the fuse holder cap and fuse.

4. Replace the defective line power fuse with a fuse of the correct type. Use fuse type MDX 2A for the 100, 110, 115, and 120V ac line voltage ranges. Use Fuse type MDX 1A for the 200, 220, 230, and 240V ac line voltage ranges.

5. Install the fuse and fuse cap.

6. Connect line power

2-21. IEEE-488 Interface Setup

2-22 INTRODUCTION

2-23. The IEEE-488 Connector (rear panel) mates with any standard IEEE-488 interface compatible cable. Figure 2-3 shows the pin-outs on the IEEE-488 connector

2-24 The IEEE-488 system connections must agree with the following restrictions.

1. No more than 15 devices may be connected in a single IEEE-488 Bus system.

2. The total length of cable used in one IEEE-488 Bus system must not exceed 20 meters or 2 meters times the number of devices in the system, whichever is less

2-25 IEEE-488 INTERFACE CABLE ACCESSORIES

2-26 All IEEE-488 interface cable accessories available for use with the 5440A are listed in the Accessories Section. Combinations of these cables can be used to meet the IEEE-488 Bus system cable restrictions. For example when only the 5440A is connected to a controller, the number of devices is two. According to the cable limit definition, the total length of cable must not exceed 2 meters times the number of devices. Consequently, the total length of cable must be 4 meters or less. Therefore, any one of the accessory cables can be used to connect the two instruments.

2-27. IEEE-488 ADDRESS ENTRY PROCEDURE

2-28. The IEEE-488 address is entered from the front panel as a value between 0 and 30 and is stored in the nonvolatile memory. The default value is 7. Complete the following procedure to enter an IEEE-488 address;

1. Press the SVCE (DATA ENTRY) key, then press the PORT SERV soft key, then press the IEEE ADDRS soft key.

2. The following message appears on the Alphanumeric Display:

SELECT IEEE-488 BUS ADDRESS = 07?

Where 07 is the address stored in nonvolatile memory. This number can be any decimal value from 00 through 30. The default value is 07.

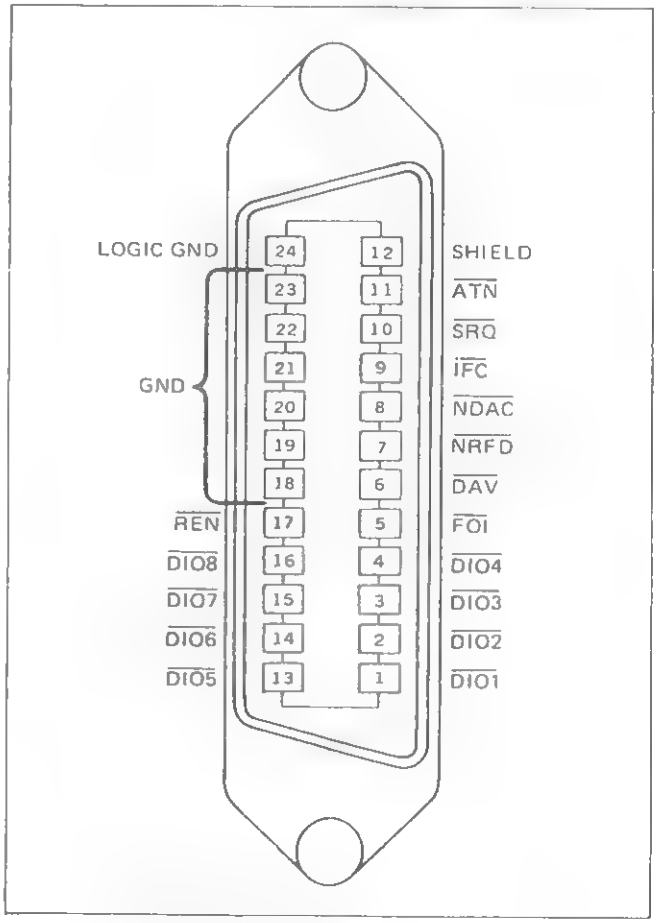


Figure 2-3. IEEE-488 Connector

3. Enter the new IEEE-488 address using the (DATA ENTRY) keys. The new address appears on the Alphanumeric Display.

4. Press ENTER/YES. The new IEEE-488 address is entered in nonvolatile memory.

2-29. RS-232-C Interface Setup

2-30. INTRODUCTION

2-31. The information in the following paragraphs provide the information necessary to configure the 5440A for RS-232-C operation. This information describes the RS-232-C connector and the RS-232-C shorting plug and procedures for configuring the shorting plug and for selecting the baud rate. The RS-232-C cables available for use with the 5440A are described in the Accessory section of this manual.

2-32. RS-232-C CONNECTOR AND SHORTING PLUG INFORMATION

2-33. Figure 2-2 shows the locations of the RS-232-C Connector and the RS-232-C Shorting Plug. The RS-232-C Connector mates with any standard (male) RS-232-C cable. This RS-232-C connector is hardwired through the RS-232-C shorting plug to the RS-232-C interface circuit inside of the 5440A. The sense of the hardwired lines of the interface are selected by changing the jumper configuration on the shorting plug. Figure 2-4 shows the shorting plug and defines the various possible configurations.

2-34. RS-232-C BAUD RATE SELECTION PROCEDURE

2-35. The 5440A is factory set to the baud rate of 2400. However, a different baud rate can be selected from the front panel. Complete the following procedure to select a new baud rate:

1. Press the SVCE (DATA ENTRY) key then press the PORT SERV soft key then press the RS232 BAUD soft key.

2. The following menu appears in the Alphanumeric Display:

SLOWER	2400	FASTER
RS232	BAUD	RS232

Where 2400 is the baud rate stored in the nonvolatile memory. (This number can be any legitimate baud rate.)

4. Press the appropriate soft key on the right or left side until the desired baud rate appears over the center soft key.

5. Press the center soft key. The following message appears on the Alphanumeric Display:

WRITING TO NV MEMORY WAIT

6. When VOLTAGE MODE appears in Alphanumeric Display, the new baud rate is stored in nonvolatile memory.

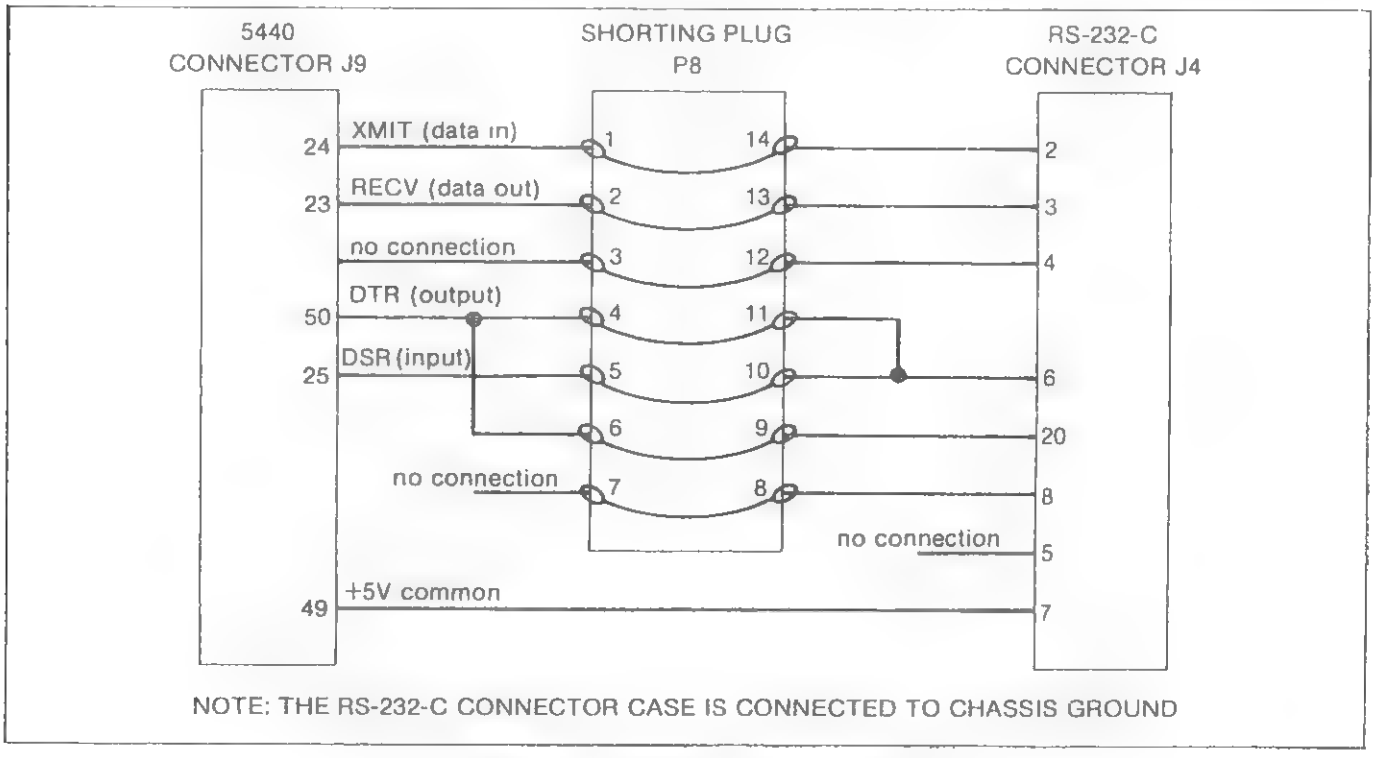


Figure 2-4. RS-232-C Shorting Plug

2-36. OPERATING NOTES

2-37. Introduction

2-38. The following paragraphs provide the background information necessary to properly operate the 5440A. Read and thoroughly understand this information before attempting to operate the 5440A.

2-39. Power On Reset State

2-40. When power is turned on or when the RESET key is pressed, the 5440A resets to a power on default state. This state is defined in Table 2-3.

Table 2-3. Voltage Mode Default Parameters

ITEM	PARAMETER
Output Voltage	0 mV
Error Mode Reference	0 mV
Voltage Limits	+1100V dc, -1100V dc
Current Limits	±25 mA dc
Floor Voltage	0 uV
Percent of Reading	0 Percent
Instrument Status	Standby Internal Sensing Divider Off Internal Guard

2-41. Operating Modes

2-42. The 5440A has three operating modes: Voltage, Voltage Boost, and Current Boost. The 5440A provides a reference voltage output in all three modes, but in the two boost modes, the 5440A output drives another instrument to provide a calibration system output.

2-43. The Voltage Mode is the normal stand-alone mode of operation for the 5440A. In the Voltage Mode, the 5440A can output voltages from -1100 to +1100V dc at currents up to 25 mA. The output is present at either the divider or output terminals when in the 5440A is in Operate (OPER). The Voltage Mode default parameters are the same as those described earlier in this section for the Power On Reset State.

2-44. For Voltage Boost operation, the 5440A must be connected to a 5205A Precision Power Amplifier via the Boost Interface. The 5440A voltage boost output range is from -15 to -1V dc and +1 to +15 dc. Since the 5440A assumes that for every 1 volt it outputs the precision power amplifier outputs 100 volts, the 5440A Output Display is 100 times the boost output for a range of -1500 to -100V dc and +100 to +1500 dc. The system output agrees with the 5440A Output Display. The default state parameters for the Voltage Boost Mode are listed in Table 2-4.

2-45 For Current Boost operation, the 5440A must be connected to a 5220A Transconductance Amplifier via the Boost Interface. The 5440A boost output can range from -20 to +20V dc Since the 5440A assumes that for every 1 volt it outputs, the transconductance amplifier outputs 1 amp, the 5440A Output Display units are in amps for a range of -20 to +20A dc. The system output agrees with the 5440A Output Display. The default state parameters for the Current Boost Mode are listed in Table 2-5.

Table 2-4. Voltage Boost Mode Default Parameters

ITEM	PARAMETERS
Output Voltage	100V dc
Reference Voltage	100V dc
Voltage Limits	+1500V dc, -1500V dc
Floor Voltage	0 uV
Percent of Reading	0 Percent
Instrument Status	Standby

Table 2-5. Current Boost Mode Default Parameters

ITEM	PARAMETERS
Output Current	0 ampere
Reference Current	0 ampere
Current Limits	+20A, -20A
Floor Current	0 uA
Percent of Reading	0 percent
Instrument Status	Standby

2-46. Warm-up Time

2-47. Warm-up time is time that the 5440A must have power turned on before the output is stable. The 5440A must be warmed up a minimum of two hours to ensure that the output meets the specifications listed in Section 1. If the 5540A is turned off (after being warmed up), the 5440A must be warmed up a minimum of twice the time it was turned off (up to a maximum of 2 hours) before the output is stable again.

2-48. Internal Calibration

2-49. The internal calibration is an automatic procedure that enhances the 5440A output accuracy. The procedure measures the 5440A output voltage internally and calculates and stores calibration constants that correct the 5440A output for zero and gain shift errors. The Internal Calibration Procedure (described in the 5440A Service Manual) should be performed two times:

1. Daily after warm-up.

2. Within 10 minutes prior to performing an external calibration.

2-50. The measurements taken by INT CAL can be printed via the RS-232-C interface during the internal Calibration. The calibration constants can be read from the front panel or via the IEEE-488 interface or via the RS-232-C interface after the Internal Calibration is complete.

2-51. External Calibration

2-52. The External Calibration is a semi-automatic procedure that corrects the 5440A output for long term drift of the internal voltage reference. An External Calibration should be performed at an interval from 30 days to one year depending upon the desired level of accuracy to be maintained. During the External Calibration procedures, the 5440A output is compared to External Reference standards in each output voltage range. The 5440A then calculates and stores calibration constants. These corrections are applied automatically when the 5440A is used. The calibration constants can be printed via the RS-232-C interface or be read from the front panel or via the IEEE-488 interface after the Internal Calibration or External Calibration is complete.

2-53. Sense Circuit

CAUTION

To prevent loss of regulation and possible damage to the instrument, ensure that the polarity of the SENSE terminals is correct when connecting them to the load.

2-54. The 5440A sense circuit can be configured for either internal or external sensing. During internal sensing, the EXT indicator is not lit over the SENSE (OUTPUT STATE) key and the SENSE circuitry is internally connected to the output terminals. There is no compensation for test lead and load resistance during internal sensing. During external sensing, the EXT indicator is lit over the SENSE (OUTPUT STATE) key, the user connects the sense terminals to an external load (Figure 2-5) and the 5440A compensates for the effects of the test-lead and load resistance on the 5440A output. High Impedance Sensing (hZs®) Virtually eliminates current flow in the test leads connected to the SENSE terminal. This provides full accuracy performance with as much as 2Ω of resistance in the test leads connected to the SENSE and OUTPUT terminals.

2-55. Guard Circuit

2-56. The 5440A guard circuit can be connected to the OUTPUT LOW terminal internally or externally. With the default internal connection, the 5440A guard circuit forms an EMI (electro-magnetic interference) shield around the analog circuits. When the guard circuit is connected internally and the 5440A is connected to another instrument, a potential difference can exist between the line power grounds of the two instruments. This potential difference can create circulating ground currents, which cause errors in the output voltage (Figure 2-6). To prevent errors due to circulating ground currents, connect the GUARD terminal directly to the low side of the load, at the load. When calibrating voltmeters with floating inputs, the following 5440A configuration usually gives the best results:

1. Press the GUARD (OUTPUT STATE) key so that the indicator is off (guard is internally connected to the OUTPUT LOW terminal).

2. Connect the shorting link between the chassis GROUND and the GUARD terminals. The 5440A is shipped with a shorting link in this configuration.

2-57. Error Code Interpretation

2-58. The 5440A has extensive diagnostic and monitoring capabilities. The 5440A displays an error code message in the Alphanumeric Display and sends a report on the IEEE-488 interface any time an error condition is detected. Table 2-6 lists the error codes caused by operator errors either from the front panel or via the IEEE-488 interface. Other error code messages indicate a fault in the 5440A. Record the message then see the Troubleshooting section of the 5440A Service Manual for more information about the fault error code messages.

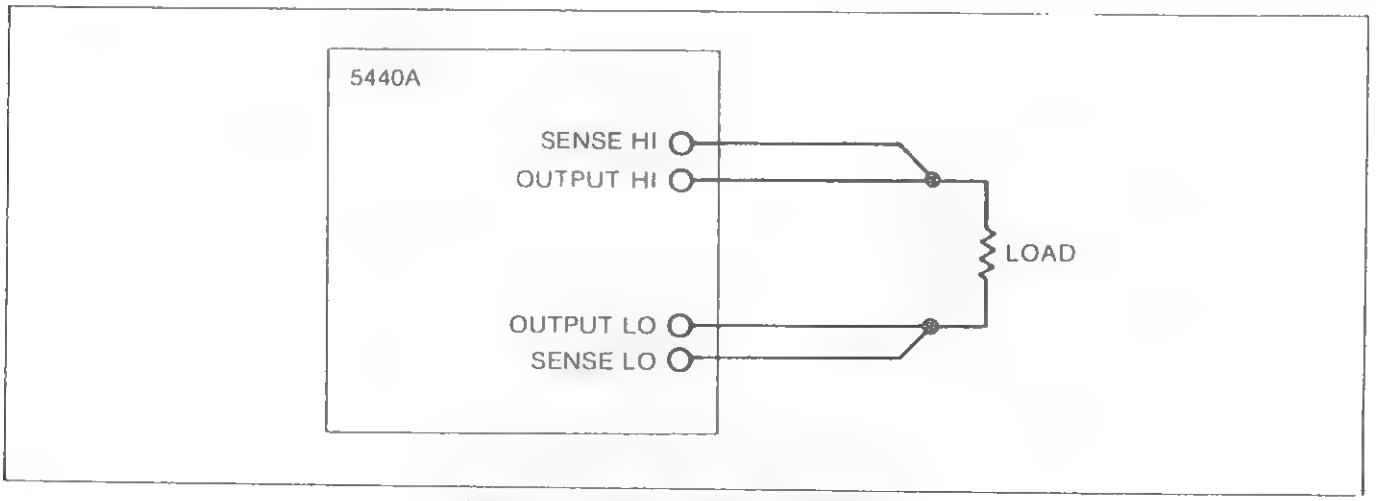
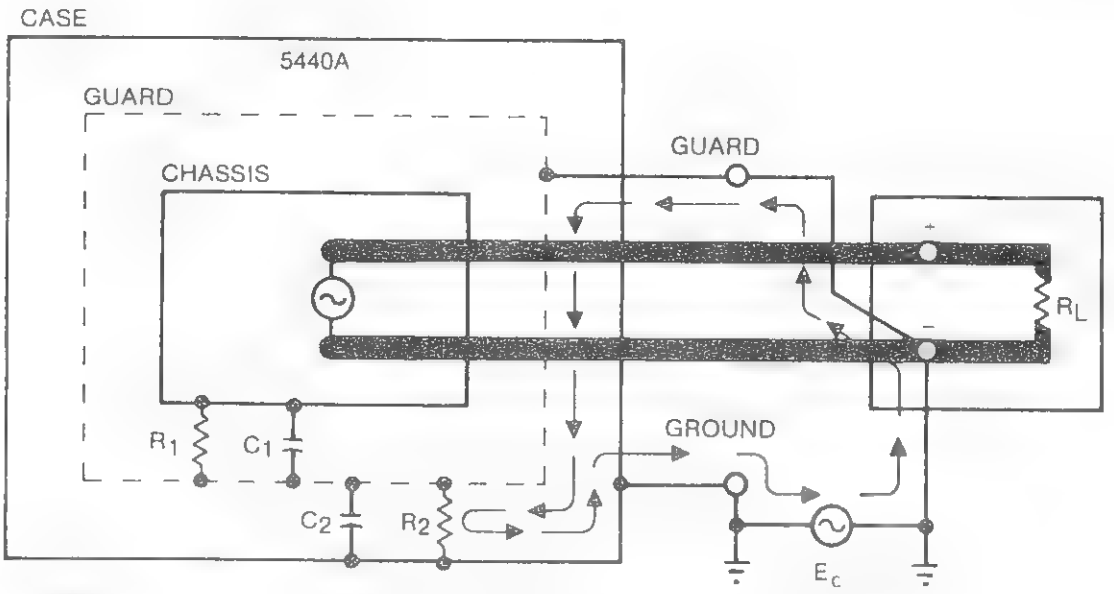


Figure 2-5. External Sense Connection



WHERE R_1 & C_1 = Leakage resistance & capacitance from chassis to guard

R_2 & C_2 = Leakage resistance & capacitance from guard to instrument case

E_c = Potential difference between power line ground points

R_L = Load resistance

Figure 2-6. Proper External Guard Connection

Table 2-6. 5440A Operator Error Codes

5440A ERROR MESSAGE		COMMENTS
ALPHANUMERIC DISPLAY	**IEEE-488 REPORT**	
BOOST INTERF ERROR CHECK REAR CONNECTOR	144	The wrong type instrument is connected to the Boost Interface.
BOOST INTERF ERROR MISSING REAR CABLE	145	No instrument is connected to the Boost Interface.
BOOST INTERF ERROR VOLTAGE TRIP	146	Voltage boost trip.
BOOST INTERF ERROR CURRENT TRIP	147	Current boost trip.
IEEE488 REMOTE ERROR SOURCE HANDSHAKE	152	IEEE-488 interface source handshake error.
IEEE488 REMOTE ERROR EXPECTING TERMINATOR	153	IEEE-488 interface terminator error. The 5440A received a carriage return (CR) without a line feed (LF).
IEEE488 REMOTE ERROR EXPECTING SEPARATOR	154	IEEE-488 interface separator error. The 5440A received a Statement from which a separator was missing.
IEEE488 REMOTE ERROR EXPECTING HEADER	155	IEEE-488 interface header error. The 5440A received a Statement with an invalid header.
IEEE488 REMOTE ERROR EXPECTING NUMBER	156	IEEE-488 interface numeric error. The 5440A received a Statement with an invalid numeric string.

Table 2-6. 5440A Operator Error Codes (cont)

5440A ERROR MESSAGE		COMMENTS
ALPHANUMERIC DISPLAY	IEEE-488 REPORT	
IEEE488 REMOTE ERROR BUFFER OVERFLOW	157	IEEE-488 interface buffer overflow. The 5440A received a Statement with more than 127 characters.
IEEE488 REMOTE ERROR BAD CHARACTER	158	IEEE-488 interface character error. The 5440A received an invalid character.
RS232C SERIAL ERROR	160	The printer port handshake timed out. This means that the handshake on the RS-232-C interface was not completed.
USER ENTRY ERROR NUMBER OUT OF RANGE	168	A numeric parameter entered at the front panel was not within the allowable range for that parameter
USER ENTRY ERROR OUTPUT OUT OF RANGE	169	An output was entered at the front panel that was not within the output entry limits for that operating mode.
USER ENTRY ERROR LIMITS OUT OF RANGE	170	A limit was entered at the front panel that was not within the allowable maximums and minimums for that limit.
USER ENTRY ERROR DIVIDER OUT OF RANGE	171	The DIV OUTPUT STATE key was used incorrectly.
USER ENTRY ERROR IN OUTPUT TERMINAL	172	The SENSE OUTPUT STATE key was used incorrectly.
USER ENTRY ERROR IN OUTPUT TERMINAL	173	The GUARD OUTPUT STATE key was used incorrectly.
USER ENTRY ERROR INSTRUMENT IS BUSY	175	A command was entered, from the front panel, that is not allowed in the present instrument state.
STORAGE MODULE ERROR CANNOT READ MODULE	None	Data could not be read from the 5440A-7001 Storage Module.
STORAGE MODULE ERROR CANNOT WRITE MODULE	None	Data could not be written into the 5440A-7001 Storage Module.
SEQUENCING ERROR MUST XFR MOD TO MEM	None	There is no test sequence in sequence memory
SEQUENCING ERROR NO SUCH STEP NUMBER	None	The step number selected is not in sequence memory.
SEQUENCING ERROR SEQ MEMORY IS FULL	None	Sequence memory is full.
SEQUENCING ERROR BAD STEP IN SEQ MEM	None	There is a bad step in sequence memory.

Section 3
Local Operation

3-1. INTRODUCTION

3-2. The information in this section describes operation of the 5440A Direct Voltage Calibrator from the front panel. Each operator should read and tho roughly understand the information in this section and in Section 2 before attempting to operate the 5440A. Remote operation via the IEEE-488 Interface is described in Section 4.

3-3. EQUIPMENT PREPARATION

WARNING

TO AVOID ELECTRICAL SHOCK HAZARDS DO NOT TOUCH OR COME IN CONTACT WITH THE OUTPUT TERMINALS WHEN LETHAL VOLTAGES ARE SELECTED FOR INSTRUMENT OUTPUT. WHEN THE POWER ON AND OPR INDICATORS ARE LIT, THE INSTRUMENT OUTPUT IS PRESENT AT THE OUTPUT, SENSE, OR DIVIDER TERMINALS DEPENDING UPON THE OUTPUT STATE SELECTED.

3-4. Before attempting to operate the 5440A, complete the appropriate items from the following list:

1. Install the 5440A according to Section 2 as follows:

   a. Rack mount or place the 5440A on a bench.

   b. Verify that the 5440A is configured for the correct line voltage and has the correct type fuse. Connect the 5440a to line power.

   c. Make the applicable connections between the 5440A OUTPUT, DIVIDER, SENSE, and GUARD terminals and the unit under test.

   d. Complete the applicable IEEE-488 and RS-232-C interface connections.

2. If one of the boost modes is to be used, make the proper connections between the 5440A and the boost instrument.

3. Connect the printer, if one is used.

3-5. POWER UP

3-6. Complete the following procedure to power up the 5440A:

1. Press the POWER key.

2. Verify that the POWER and STBY indicators light and that VOLTAGE MODE appears on the Alphanumeric Display. The 5440A is in the power up reset state described in Section 2.

3. Connect the printer, if one is used.

3-7. LOCAL/REMOTE SELECTION

3-8. The 5440A is in local operation when it is not connected to the IEEE-488 interface. When the 5440A is connected to the IEEE-488 interface, the Local/Remote state is determined by the IEEE-488 interface controller as described in Section 4.

3-9. DATA ENTRY

3-10. Introduction

3-11. Figure 3-I shows the (DATA ENTRY) keyboard. The upper row of keys are used to select Soft Key menus. The lower three rows of keys are used for two types of data entry operations: Answer Entry and Number Entry.

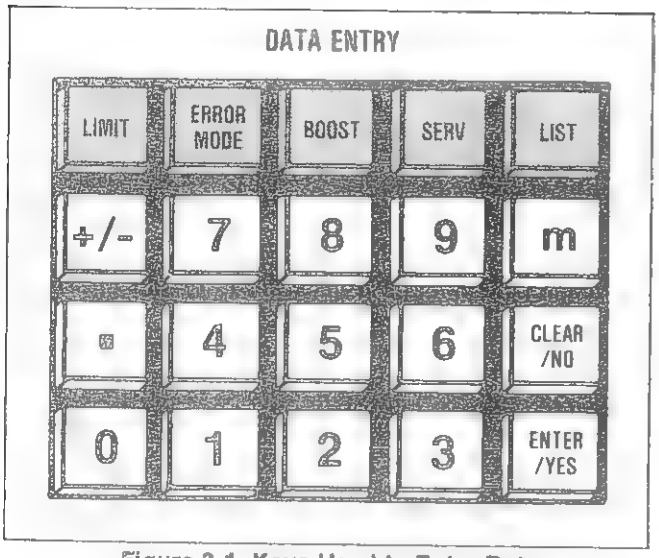


Figure 3-1. Keys Used to Enter Data

3-12. Answer Entry

3-13. When an operation asks a question, the operator must answer yes or no to proceed. Press the CLEAR/NO (DATA ENTRY) key to answer no. Press the ENTER/YES (DATA ENTRY) key to answer yes.

3-14. Number Entry

3-15. Many types of 5440A local operation require an integer or a floating point number to be entered in one or two data fields. The type of local operation determines the number of fields and the type of data to be entered. For example, when the IEEE-488 address is to be entered, the 5440A displays the current or default IEEE-488 address in the Alphanumeric Display followed by a question mark. The IEEE-488 address is an integer and will not accept a floating point entry.

3-16. When an operation is selected that allows the operator to enter a number the default or current value appears in the Alphanumeric Display followed by a question mark. The blinking cursor appears at the most significant digit. If the first legitimate key pressed is not the right arrow key or the left arrow key (below the Alphanumeric Display), the display is cleared and the key entry is made. For example, if the number to be entered is a floating point number and the 8 (DATA ENTRY) key is pressed, the Alphanumeric Display clears and 8. appears in the display with the blinking cursor at the decimal position.

3-17. All 15 keys in the lower three rows of (DATA ENTRY) keys may be used to enter an integer or a floating point number. The keys function as follows:

1. The digit keys 0 through 9 enter the corresponding digit each time they are pressed.

2. The decimal point (.) (DATA ENTRY) key fixes the decimal position in floating point numbers. This key is ignored (not legitimate) for integer entries.

3. The ± (DATA ENTRY) key changes the sign of the number if the sign is allowed to change. For example, the two numeric fields in Voltage Limits entry are predetermined to be positive and negative. the ± (DATA ENTRY) key cannot change the sign of these fields.

4. The m (DATA ENTRY) key selects the units for some floating point numbers. These units can be m (milli), u (micro), or a blank space for whole units (volts, amperes, etc.). The local operation selected determines whether the m (DATA ENTRY) key toggles between m and u or between m and a blank space. This key is ignored (not legitimate) for integer entries.

5. The CLEAR/NO (DATA ENTRY) and the ENTRY/YES (DATA ENTRY) keys terminate number entries. Press the CLEAR/NO (DATA ENTRY) key to clear the entry from the Alphanumeric Display (the 5440A continues to use the default or current number). Press the ENTER/YES (DATA ENTRY) key to enter the number.

3-18. To clarify Data Entry operations, complete the following example procedure to enter three different output voltages:

1. Press the RESET key. The following message appears in the Alphanumeric Display:

VOLTAGE MODE

2. Complete the following procedure to output +10 mV from the 5440A:

a. Press the 1 (DATA ENTRY) key. The Alphanumeric Display changes to the following:

VOLTAGE MODE V OUT
= +1.0000000 V?

b. Press the 0 (DATA ENTRY) key. The Alphanumeric Display changes to the following:

VOLTAGE MODE V OUT
= +10.000000 V?

c. Press the m (DATA ENTRY) key. The Alphanumeric Display changes to the following:

VOLTAGE MODE V OUT
= +10.000000mV?

d. Press the ENTER/YES (DATA ENTRY) key. The Alphanumeric Display changes back to VOLTAGE MODE and the following appears in the Output Display:

+00010.000mV

e. Press the OPR/STBY (OUTPUT STATE) key. The STBY indicator turns off and the OPR indicator lights. The +10 mV is available on the OUTPUT terminals.

3. Complete the following procedure to output -100 mV from the 5440A:

a. Press the 1 (DATA ENTRY) key. The Alphanumeric Display changes to the following:

VOLTAGE MODE V OUT
= +1.0000000 V?

b. Press the 0 (DATA ENTRY) key twice. The Alphanumeric Display changes to the following:

VOLTAGE MODE V OUT
= +1001.00000 V?

c. Press the m(DATA ENTRY) key. The Alphanumeric Display changes to the following:

VOLTAGE MODE V OUT
= +100.00000mV?

d. Press the ± (DATA ENTRY) key. The Alphanumeric Display changes to the following:

VOLTAGE MODE V OUT
= -100.00000mV?

e. Press the ENTER/YES (DATA ENTRY) key. The Alphanumeric Display changes back to VOLTAGE MODE, the -100 mV is available at the OUTPUT terminals, and the following appears in the Output Display:

-00100.000mV

4. Complete the following procedure to output +30V from the 5440A:

a. Press the 3 (DATA ENTRY) key. The Alphanumeric Display changes to the following:

VOLTAGE MODE V OUT
= +3.0000000 V?

b. Press the 0 (DATA ENTRY) key. The Alphanumeric Display changes to the following:

VOLTAGE MODE V OUT
= +30.000000 V?

c. Press the ENTER/YES (DATA ENTRY) key. The Alphanumeric Display changes back to VOLTAGE MODE and the following appears in the Output Display:

+030.00000 V

NOTE

The 5440A automatically entered standby when the output voltage was shifted from -100 mV to +30V to protect the operator from a possible shock hazard. This automatic shift to standby occurs whenever the 5440A is in operate and the output voltage is programmed from an output voltage between -22V to +22V to an output voltage less than -22V or greater than +22V.

d. Press the OPR/STBY (OUTPUT STATE) key. The +30V is available on the OUTPUT terminals.

3-19. VOLTAGE MODE OPERATION

3-20. Use the following steps as a guide for operating the 5440A from the front panel in the Voltage Mode. Actual operation may vary from the sequential steps listed below. Operation of the (EDIT OUTPUT), and (MEMORY) keys is described later in this section.

1. Place the 5440A in the Power up reset state.

2. Use the (DATA ENTRY) keys to enter the value of the desired output voltage. This value appears in the Alphanumeric Display. The output voltage entered now appears in the Output Display.

3. Press the OPR/STBY key so that the OPR indicator lights. The 5440A output is applied to the OUTPUT or DIVIDER terminals and the value of the voltage appears in the Output Display.

3-21. DIVIDER OPERATION

3-22. The DIV (OUTPUT STATE) key controls the DIVIDER output terminals. When the DIV (OUTPUT STATE) key is pressed, the divider ON indicator lights for a programmed output from -2.2V dc to +2.2V dc. The divider circuit does not function in the Voltage Boost or Current Boost modes.

3-23. Complete the following procedure for Divider Operation:

1. Place the 5440A in Voltage Mode Operation.

2. Verify the the DIVIDER terminals are correctly connected to the device under test.

3. Press the DIV (OUTPUT STATE) key.The divider ON indicator lights.

4. Use the (DATA ENTRY) keys to enter the desired output voltage.

5. Press the OPR/STBY (OUTPUT STATE) key. The OPR indicator lights and the programmed voltage is present on the DIVIDER terminals.

3-24. EDIT OUTPUT OPERATIONS

3-25. Introduction

3-26. The (EDIT OUTPUT) keys located beneath the Output Display, (Figure 3-2) allow the operator to edit the value shown in the Output Display. There are two types of Edit Output Operations: arrow key and labeled key.

3-27. Edit Output Arrow Key Operations

3-28. The right and left arrow (EDIT OUTPUT) keys move the cursor position in the Output Display right and left, respectively. The cursor cannot be moved to the 1000 digit position in the Voltage Mode or the Voltage Boost Mode. The cursor cannot be moved to the 10 digit position in the Current Boost Mode. The up and down arrow (EDIT OUTPUT) keys respectively increment and decrement the value of the digit at the cursor position of the Output Display. The up and down arrow keys repeat their function about three times a second as long as the keys are held down.

3-29. Edit Output Labeled Key Operations

3-30. As Figure 3-2 shows, there are three labeled (EDIT OUTPUT) keys: CHNG SIGN, RCALL REF, and NEW REF. Press the CHNG SIGN (EDIT OUTPUT) key to switch the polarity of the output signal. Press the RCALL REF (EDIT OUTPUT) key to recall the (nominal) output reference from memory. Press the NEW REF (EDIT OUTPUT) key to store the present output as the nominal reference. The value of this nominal reference is used to calculate percent deviation during % ERROR operation.

3-31. MEMORY CONTROL OPERATIONS

3-32. The (MEMORY CONTROL) keys (Figure 3-3) allow the user to build or modify sequences of steps in the internal sequence memory. The sequence memory can hold up to 60 steps which are clear at power on. (The RESET key does not clear sequence memory.) Each step can contain eight types of setup data about the 5440A.

1. Operating Mode: Voltage, Voltage Boost, or Current Boost

2. Output State: Operate/Standby, Internal/ External Sense, Divider ON/OFF, Internal/ External Guard.

3. Error Mode display information.

4. Output Value; which is also the (nominal) output reference.

5. Output Display cursor location.

6. Voltage Limits (when applicable).

7. Current Limits (when applicable).

8. Tolerance Specifications for output edit (when applicable).

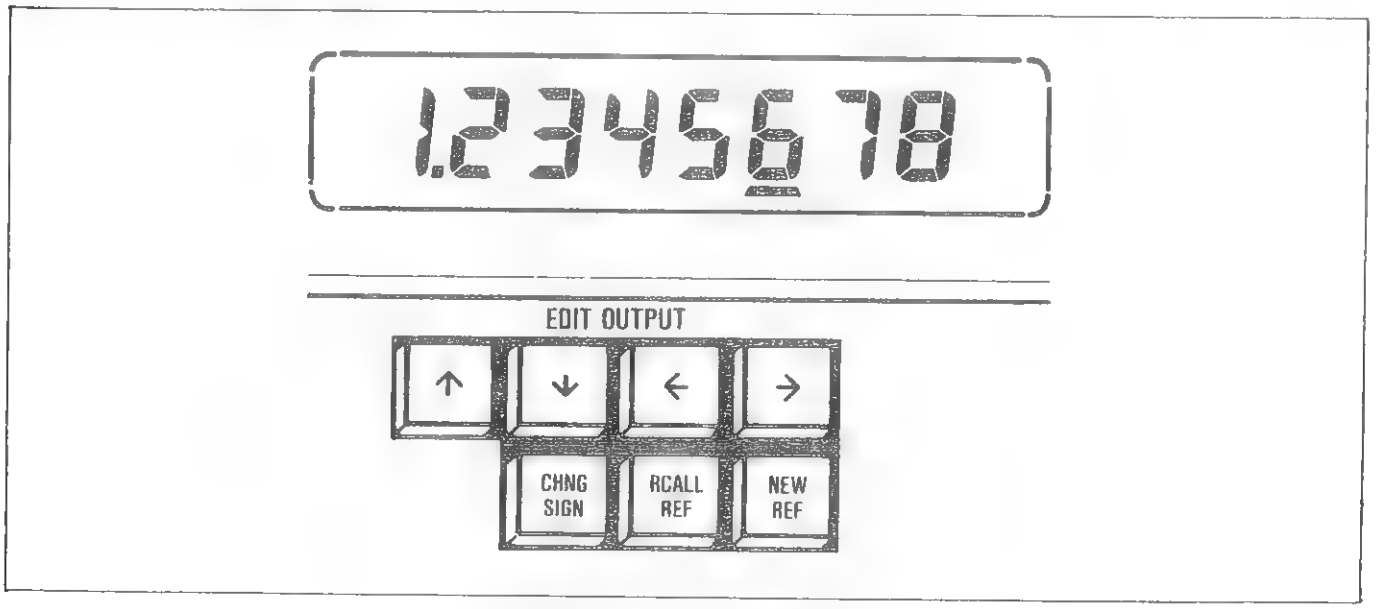


Figure 3-2. Edit Output Keys

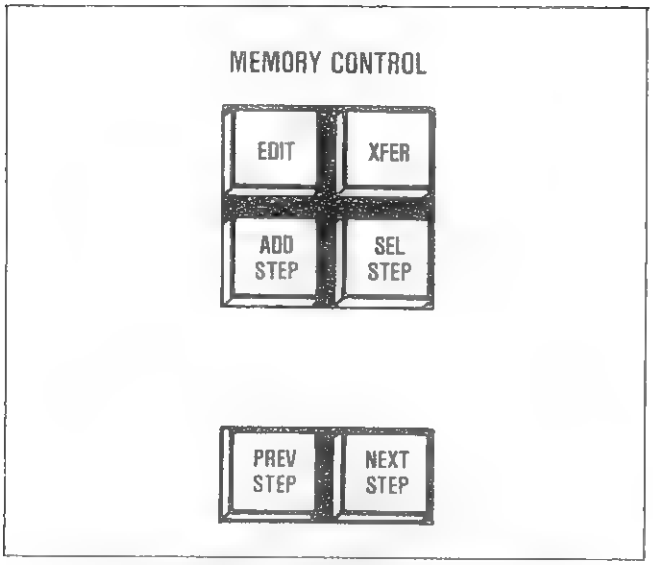


Figure 3-3. Memory Control Keys

3-33. The EDIT and XFER (MEMORY CONTROL) keys select soft key menus. These keys are described later in this section. The other four keys have the following functions:

1. Pressing ADD STEP (MEMORY CONTROL) adds the present 5440A front panel setup to sequence memory as the step number shown in the upper right corner of the Alphanumeric Display (for example, if there were 11 steps, S12 would appear in the display for the added step 12).

2. Pressing the SEL STEP (MEMORY CONTROL) key followed by a step number recalls the front panel setup stored at that step number.

3. Pressing PREV STEP (MEMORY CONTROL) recalls the front panel setup stored at the sequence memory location that is one step before (less than) the location displayed in the upper right corner of the Alphanumeric Display.

4. Pressing NEXT STEP (MEMORY CONTROL) recalls the front panel setup stored at the sequence memory location that is one step after (greater than) the location displayed in the upper right corner of the Alphanumeric Display.

3-34. SOFT KEY OPERATIONS

WARNING

TO AVOID SHOCK HAZARD, NEVER MAKE ELECTRICAL CONTACT WITH THE OUTPUT HI OR SENSE HI TERMINALS OF THE 5440A. LETHAL VOLTAGES MAY BE PRESENT ON THESE TERMINALS DURING NORMAL OPERATION AND SYSTEM SELF TEST OR WHEN A FAULT CONDITION EXISTS.

3-35. As Figure 3-4 shows, the keys that affect soft key operations are the three unlabeled keys under the Alpahnumeric Display and the top row of (DATA ENTRY) and (MEMORY CONTROL) keys. The top row of (DATA ENTRY) and (MEMORY CONTROL) keys select soft key menus. When any of these seven menu selection keys are pressed, the unlabeled keys select the menu functions that appear above the unlabeled keys in the Alphanumeric Display. Figure 3-4 is a tree structure that shows the soft key operations that branch from each of the (DATA ENTRY) and (MEMORY CONTROL) keys. Table 3-1 defines these soft key operations.

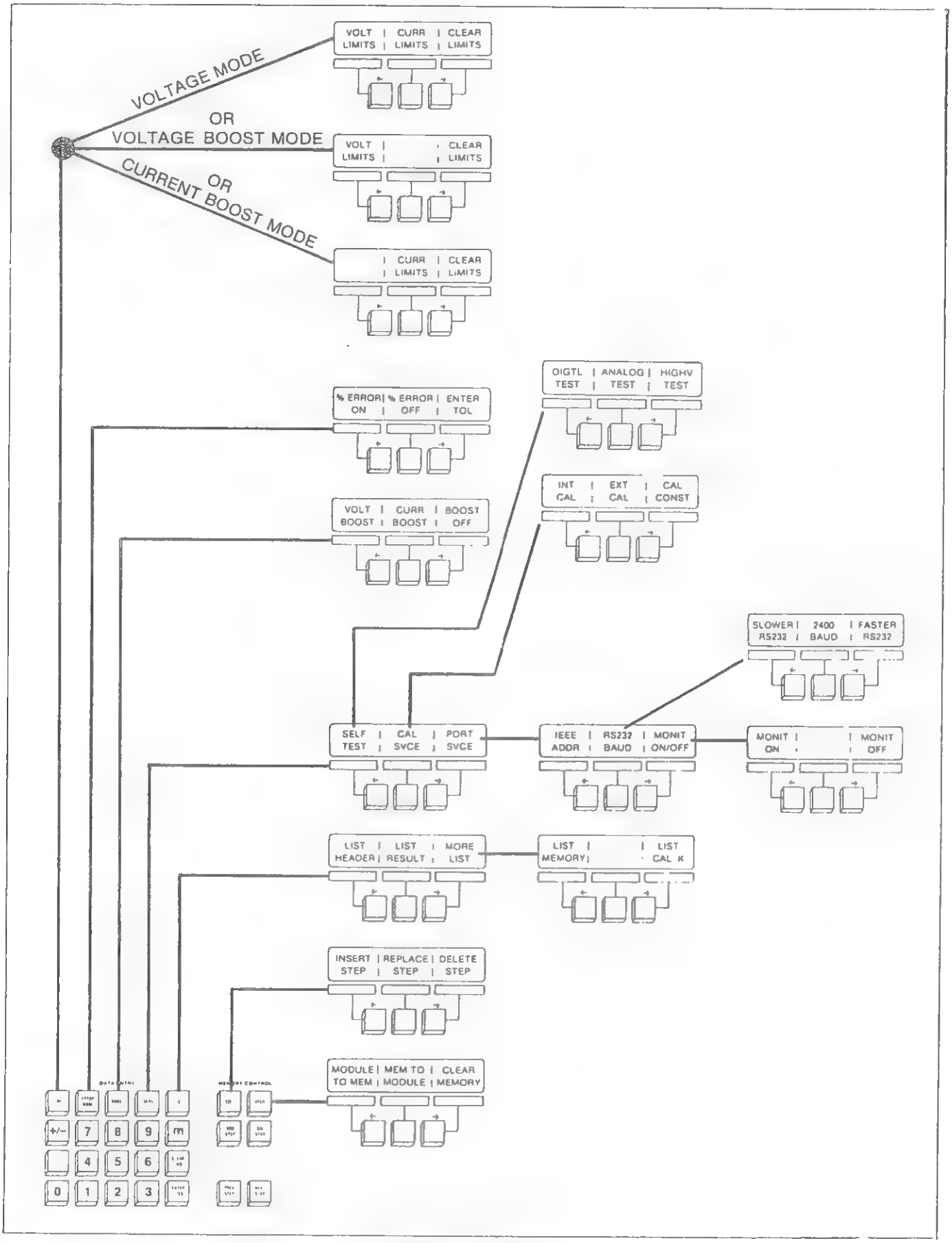


Figure 3-4. Soft Keys

FRONT PANEL KEY NAME	OPERATING MODE	SOFT KEY NAME	FUNCTION
LIMIT	VOLTAGE	VOLT LIMITS	Press to enter new voltage limits. The following message appears in the Alphanumeric Display: V LIM = +1100.000 V V LIM = -1100.000 V? Where the two numbers are the last voltage limits set. The cursor is at the most significant digit of the upper field. Press the center soft key to move the cursor from one field to the other. The m (DATA ENTRY) key toggles the units between V and mV. The +/- (DATA ENTRY) key is ignored. The largest entry allowed is 1100V.
		CURR LIMITS	Press to enter a new current trip point. The following message appears in the Alphanumeric Display: CURR LIM = ±25.0 mA? Where the number is the last current trip point entered. The cursor is at the most significant digit. The m (DATA ENTRY) key toggles the units between A and mA. The +/- (DATA ENTRY) key is ignored because the current trip entry is an absolute value. The largest entry allowed is 25.0 mA.
		CLEAR LIMITS	Press to set the limits to the default value.
	VOLTAGE BOOST	VOLT LIMITS	Press to enter new voltage limits. The following message appears in the Alphanumeric Display: V LIM = +1500.000 V V LIM = -1500.000 V? Where the two numbers are the last voltage limits set. The cursor is at the most significant digit of the upper field. Press the center key to move the cursor from one field to the other.

Table 3-1. Definition of Soft Key Functions

Table 3-1. Definition of Soft Key Functions (cont)

FRONT PANEL KEY NAME	OPERATING MODE	SOFT KEY NAME	FUNCTION
LIMIT (cont)	VOLTAGE BOOST (cont)	VOLT LIMITS (cont)	The m (DATA ENTRY) key toggles the units between V and mV. The +/- (DATA ENTRY) key is ignored. The largest value allowed is 1500V.
		(blank)	No function.
		CLEAR LIMITS	Press to set the limits to the default value.
	CURRENT BOOST	(blank)	No function.
		CURR LIMITS	Press to enter new current limits. The following message appears in the Alphanumeric Display: CURR LIM = +20.000 A CURR LIM = -20.000 A? Where the two numbers are the last voltage limits set. The cursor is at the most significant digit of the upper field. Press the center soft key to move the cursor from one field to the other. The m (DATA ENTRY) key toggles the units between A and mA. The +/- (DATA ENTRY) key is ignored. The largest value allowed is 20A.
		CLEAR LIMITS	Press to set the limits to the default value.
ERROR MODE	N/A	%ERROR ON	Press to display the deviation of the actual output from the stored error reference value as a percentage. If the deviation is less than 0.1%, the error is displayed in parts per million.
		%ERROR OFF	Press to stop displaying the percentage error.
		ENTER TOL	Press to enter the percentage of error and the tolerance floor. One of the following messages appears in the Alphanumeric Display. ENTER TOLERANCE +/-(.00123% +5.00 uV)? ENTER TOLERANCE +/-(.00123% +5.00 uA)?

Table 3-1. Definition of Soft Key Functions (cont)

FRONT PANEL KEY NAME	OPERATING MODE	SOFT KEY NAME		FUNCTION
ERROR MODE (cont)	N/A	ENTER TOL (cont)		Where the number expressed in percent is the percentage and the number expressed in volts or amperes is the tolerance floor. Use the center soft key to move the cursor from one data field to the other. Once the data has been entered, the error message is displayed whether the %ERROR ON key has been pressed or not. If the error is less than the tolerance, then a PASS message appears in the lower right corner of the error display. If the error is greater than the tolerance, then a FAIL message appears in the lower right corner of the error display. Tolerance is computed according to the following formula. $T = \pm[(\lvert\text{percentage}\rvert \times \lvert\text{error reference}\rvert)/100 + \text{tolerance floor}\rvert]$
BOOST	N/A	VOLT BOOST		Press to select Voltage Boost Mode operation.
		CURR BOOST		Press to select Current Boost Mode operation.
		BOOST OFF		Press to select Voltage Mode operation.
SVCE	N/A	SELF TEST	DIGTL TEST	Press to start the Digital Self-test. Press RESET to stop the test.
			ANALOG TEST	Press to start the Analog Self-test. Press RESET to stop the test.
			HIGH V TEST	**WARNING** **TO AVOID SHOCK HAZARD DURING THE HIGH VOLTAGE SELF TEST, NEVER MAKE ELECTRICAL CONTACT WITH THE OUTPUT HI OR SENSE HI TERMINALS OF THE 5440A.** Press to start the High Voltage Self-Test. Press RESET to stop the test.
		CAL SVCE	INT CAL	Press to start the Internal Calibration procedure.
			EXT CAL	Press to start the External Calibration. This is a semi-automatic procedure. The 5440A prompts the technician.
			CAL CONST	Press to display the calibration constants. The 5440A displays calibration constant 00. Repeatedly press the ENTER/YES (DATA ENTRY) key to display the rest of the calibration constants in numerical sequence. Press CLEAR/NO (DATA ENTRY) to exit this function.

Table 3-1. Definition of Soft Key Functions (cont)

FRONT PANEL KEY NAME	OPERATING MODE	SOFT KEY NAME			FUNCTION
SVCE (cont)	N/A	PORT SVCE	IEEE ADDR		Press to display or change the IEEE-488 Interface address of the 5440A. Numbers from 00 through 30 can be entered. The default value is 07. The m (DATA ENTRY), . (DATA ENTRY), and +/- (DATA ENTRY) keys are ignored.
			RS232 BAUD	SLOWER RS232	Press to select a slower baud rate in the center display.
				dddd BAUD	Press to select dddd as the baud rate (where dddd is three to four digits of the baud rate).
				FASTER BAUD	Press to select a faster baud rate in the center display.
			MONIT ON/OFF	MONIT ON	Press to print information via the RS-232-C port during Internal Calibration procedures and Analog Self-tests.
				(blank)	No function.
				MONIT OFF	Press to inhibit printing information during Internal Calibration procedures and Analog Self-tests.
LIST	N/A	LIST HEADER			Press to print the appropriate header via the RS-232-C port. See Section 5 for definitions of the header formats.
		LIST RESULT			Press to print a summary of a calibration step via the RS-232-C port. See Section 5 for a definition of the results format.
		MORE LIST	LIST MEMORY		Press to print a summary of each step stored in sequence memory via the RS-232-C port. The parameters printed for each step are as follows: Output value Limits (voltage and/or current as appropriate) Tolerance specification
			(blank)		No function.
			LIST CAL. K		Press to print the calibration constants via the RS-232-C port. See Section 5 for a definition of the format.

Table 3-1. Definition of Soft Key Functions (cont.)

FRONT PANEL KEY NAME	OPERATING MODE	SOFT KEY NAME	FUNCTION
EDIT	N/A	INSERT STEP	Press to store the current front panel setup at the displayed sequence memory step number. The following message appears in the Alphanumeric Display. INSERT PRESENT SETUP BEFORE MEM STEP 0 ? Where the number is the sequence step number. Use the (DATA ENTRY) keys to change this step number. The . (DATA ENTRY), +/- (DATA ENTRY), and m (DATA ENTRY) keys are ignored.
		REPLACE STEP	Press to replace the front panel setup stored at the displayed sequence memory step number with the current front panel setup. The following message appears in the Alphanumeric Display. REPLACE MEM STEP 0 WITH PRESENT SETUP? Where the number is the sequence step number. Use the (DATA ENTRY) keys to change this step number. The . (DATA ENTRY), +/- (DATA ENTRY), and m (DATA ENTRY) keys are ignored.
		DELETE STEP	Press to delete the front panel setup stored at the displayed sequence memory step number. The following message appears in the Alphanumeric Display. DELETE STEP 0 FROM SEQUENCE IN MEMORY? Where the number is the sequence step number. Use the (DATA ENTRY) keys to change this step number. The . (DATA ENTRY), +/- (DATA ENTRY), and m (DATA ENTRY) keys are ignored.

FRONT PANEL KEY NAME	OPERATING MODE	SOFT KEY NAME	FUNCTION
XFER	N/A	MODULE TO MEM	Press to transfer the contents of the 5440A-7001 Storage Module to the sequence memory. The following message appears in the Alphanumeric Display. PRESS YES FOR MODULE TO OVERWRITE MEMORY? Press the ENTER/YES (DATA ENTRY) key to transfer the contents of the 5440A-7001 Storage Module to sequence memory. Press the CLEAR/NO (DATA ENTRY) key to exit the function without transferring data.
		MEM TO MODULE	Press to transfer the contents of sequence memory to the 5440A-7001 Storage Module. The following message appears in the Alphanumeric Display. DO YOU REALLY WANT COPY MEM TO MODULE? Press the ENTER/YES (DATA ENTRY) key to transfer the contents of sequence memory to the 5440A-7001 Storage Module. Press the CLEAR/NO (DATA ENTRY) key to exit the function without transferring data.
		CLEAR MEMORY	Press to clear sequence memory. The following message appears in the Alphanumeric Display. DO YOU REALLY WANT TO CLEAR SEQ IN MEM? Press the ENTER/YES (DATA ENTRY) key to clear sequence memory. Press the CLEAR/NO (DATA ENTRY) key to exit the function without clearing sequence memory.

Table 3-1. Definition of Soft Key Functions (cont)

Section 4
Remote Operation Via the IEEE-488 Interface

4-1. INTRODUCTION

4-2. The information in this section describes operation of the 5440A via the IEEE-488 Interface. The programmer should read and thoroughly understand the information in Section 3 (Local Operation) as well as the information in this section before attempting to program the 5440A.

4-3. The 5440A is designed in accordance with the IEEE Standard 488-1978, for use in a system configuration with any IEEE-488 controller. The 5440A is completely programmable via the IEEE-488 interface. IEEE-488 messages duplicate the function of all front panel controls except the sequencing functions.

4-4. IEEE-488 INTERFACE FUNCTIONS

4-5. Table 4-1 lists the IEEE-488 interface functions and defines the 5440A implementation.

Table 4-1. 5440A Related IEEE-488 Interface Specifications

INTERFACE FUNCTION	COMMENTS
SH1	Complete source handshake capabilities
AH1	Complete acceptor handshake capabilities
RL1	Complete remote local capabilities
T6	Basic talker, Serial poll, Unaddressed if MLA
TE0	No extended talker capabilities
L4	Basic listener, unaddressed if MLA
LE0	No extended listener capabilities
SR1	Complete service request capabilities
PP0	No parallel poll capabilities
DC1	Complete device clear capabilities
DT0	No device trigger capabilities
C0	No controller capabilities
E1	Open collector output

4-6. IEEE-488 INTERFACE BUS CONNECTION

4-7. Procedures for electrically connecting the 5440A to the IEEE-488 bus are described in Section 2.

4-8. IEEE-488 BUS ADDRESS

4-9. The 5440A IEEE-488 Bus Address can be entered from the front panel. Section 2 contains a procedure for setting the IEEE-488 Bus Address.

4-10. REMOTE AND LOCAL STATES

4-11. Introduction

4-12. The 5440A can operate in any of four Remote/Local States: Local, Local With Lockout, Remote, and Remote With Lockout. The state in which the 54440A operates is determined by the 5440A front panel controls and the IEEE-488 interface controller. The 5440A sends the Return to Local command any time a front panel key is pressed while the 5440A is in remote control.

4-13. The Local States

4-14. In both local states, the 5440A is controlled by the front panel and the LOCAL annunciator is displayed. While in the local states, the 5440A has the following characteristics:

1. The only difference between operation in the two local states is the remote state to which control is transferred when the correct My Listen Address (MLA) is sent while the REN command line is true.

   a. If the 5440A is in the Local State, the Remote State is entered.

   b. If the 5440A is in the Local With Lockout State, the Remote State With Lockout State is entered.

2. The 5440A still handshakes statements via the IEEE-488 interface but the data is ignored and discarded.

3. If the 5440A is correctly addressed to talk and has data to send (DAV true), it transmits the information even with the REN command line false. If the 5440A does not have data to transmit, DAV will be false therefore no data transfers can occur.

4-15. The Remote States

4-16. In the two remote states, the 5440A is controlled via the IEEE-488 interface and the REMOTE annunciator is displayed.

1. The only difference in operation between the two states is the message displayed on the front panel of the 5440A.

   a. In the Remote State, REMOTE CONTROL appears in the Alpha-numeric Display.

   b. In the Remote With Lockout State, REMOTE WITH LOCKOUT appears in the Alpha-numeric Display.

2. The REN command line must remain true during program data transfer or the 5440A handshakes but ignores all the data.

4-17. TIMING CONSIDERATIONS

4-18. When writing test programs, one of the most difficult considerations is timing: just how long a wait time must be allowed to insure that an instrument has executed a message and that the output of that instrument has settled? The 5440A has an output settled bit in the Serial Poll Status Byte (described later in this section) that can generate an SRQ interrupt to notify the controller when the 5440A output is settled within ± 5%. If the output voltage is not changed (for example, SOUT 1V is set twice), the second command doesn't generate an SRQ.

4-19. INPUT BUFFER

4-20. All statements received by the 5440A via the IEEE-488 interface are stored in the 127 character input buffer. If the 5440A receives a statement that has more than 127 characters, a "statement too large" error is flagged and the input buffer is cleared. If statements are being sent to the 5440A faster than the 5440 can process them, then the 5440A halts the 3-wire handshake at Ready For Data Holdoff when the input buffer fills.

4-21. IEEE-488 INTERFACE MESSAGES AND IFC COMMAND LINE

4-22. The IEEE-488 interface messages and the IFC command line are listed and defined in Table 4-2.

4-23. NOTATION AND SYNTAX CONVENTIONS

4-24. Notation and syntax conventions are used in this section. The notation conventions add clarity to the descriptions. The syntax conventions help to define the grammar of 5440A program statements. Table 4-3 lists and defines notation and syntax conventions used in this section. Figure 4-1 shows how to interpret syntax diagrams.

4-25. INCOMING CHARACTER TRANSFORMATIONS

4-26. The 5440A processes all incoming data from the IEEE-488 interface through the following transformations:

1. Bit 8 (DIO8) is ignored so that all data internal to the 5440A is 7-bit ASCII only.

2. All lower case characters are folded to upper case.

3. All characters less than 32 (SPACE) except 10 (LF) and 13 (CR) are discarded.

4-27. 5440A STATEMENT

4-28. Introduction

4-29. The 5440A statement is the minimum executable device dependent message string sent to the 5440A. No execution takes place until the 5440A receives a complete statement ended by a terminator. Figure 4-2 shows the syntactical construction allowed for 5440A statements. In addition to this syntax structure, 5440A statements must meet the following semantic rules:

1. A statement must be less than 127 characters in length including the SR2 or SR3 components (counted as one character) of the terminator.

2. A header can have a maximum of five characters.

3. A numeric must meet the following rules:

   a. The mantissa can have up to eight significant digits.

   b. The exponent can have up to two significant digits.

   c. An integer must be less than a decimal 256.

   d. A numeric must be greater than 1E-12 but less than 1E8.

Table 4-2. IEEE-488 Interface Messages and IFC Command Line

INTERFACE MNEMONIC	MESSAGE/COMMAND LINE NAME	COMMENTS
DCL	Device Clear	DCL clears the input/output data buffers, unasserts service request, and resets the 5440A to the power on reset state.
GET	Group Execute Trigger	Handshaken but ignored.
GTL	Go To Local	GTL transfers control of the 5440A from one of the remote states to one of the local states. See the Remote And Local States material earlier in this section.
IFC	Interface Clear	IEEE-488 Command Line that goes true (1) to place the interface in the idle state.
LLO	Local Lockout	LLO transfers remote/local control of the 5440A. See the Remote And Local material earlier in this section.
SDC	Selected Device Clear	SDC must be preceeded by the correct MLA. If the ATN command line is true, SDC clears the input/output data buffers, unasserts service request, and resets the 5440A to the power on reset state.
SPE	Serial Poll Enable	If the ATN command line is true, SPE configures the 5440A for serial poll
SPD	Serial Poll Disable	If the ATN command line is true, SPD disables serial poll.
PPC	Parallel Poll Configure	Handshaken but ignored.
PPU	Parallel Poll Unconfigure	Handshaken but ignored.
TCT	Take Control	Handshaken but ignored
SCG	Secondary Command Group	Handshaken but ignored.

Table 4-3. 5440A Notation and Syntax Conventions

NOTATION/ SYNTAX	MEANING
	NOTATION CONVENTIONS
CR	Carriage Return
LF	Line Feed
SPACE	Space Character
	SYNTAX CONVENTIONS
::=	The symbol to the left of the syntax notation is defined by the symbol(s) to the right of the syntax notation
< >	The symbol between the brackets can be expanded (modified or defined). Symbols not enclosed by these brackets cannot be expanded.
{ }	The symbol(s) between the brackets can be repeated zero or more times.
[ ]	The symbol(s) between the brackets is optional.
|	The symbols on either side of the syntax notation are logically ORed

Boldface character(s) in a circular enclosure represents one ASCII character. For example, the ASCII character for carriage return appears as:

Lower case words in a rectangular enclosure represent information to be defined by the user. In the following example, the user enters a digit.

Flow follows the arrows and is usually from left to right. Slanted lines assist in directing flow. In the example below, the slanted lines direct flow back through the box to indicate that one or more digits is to be entered.

Figure 4-1. Syntax Diagram Interpretation

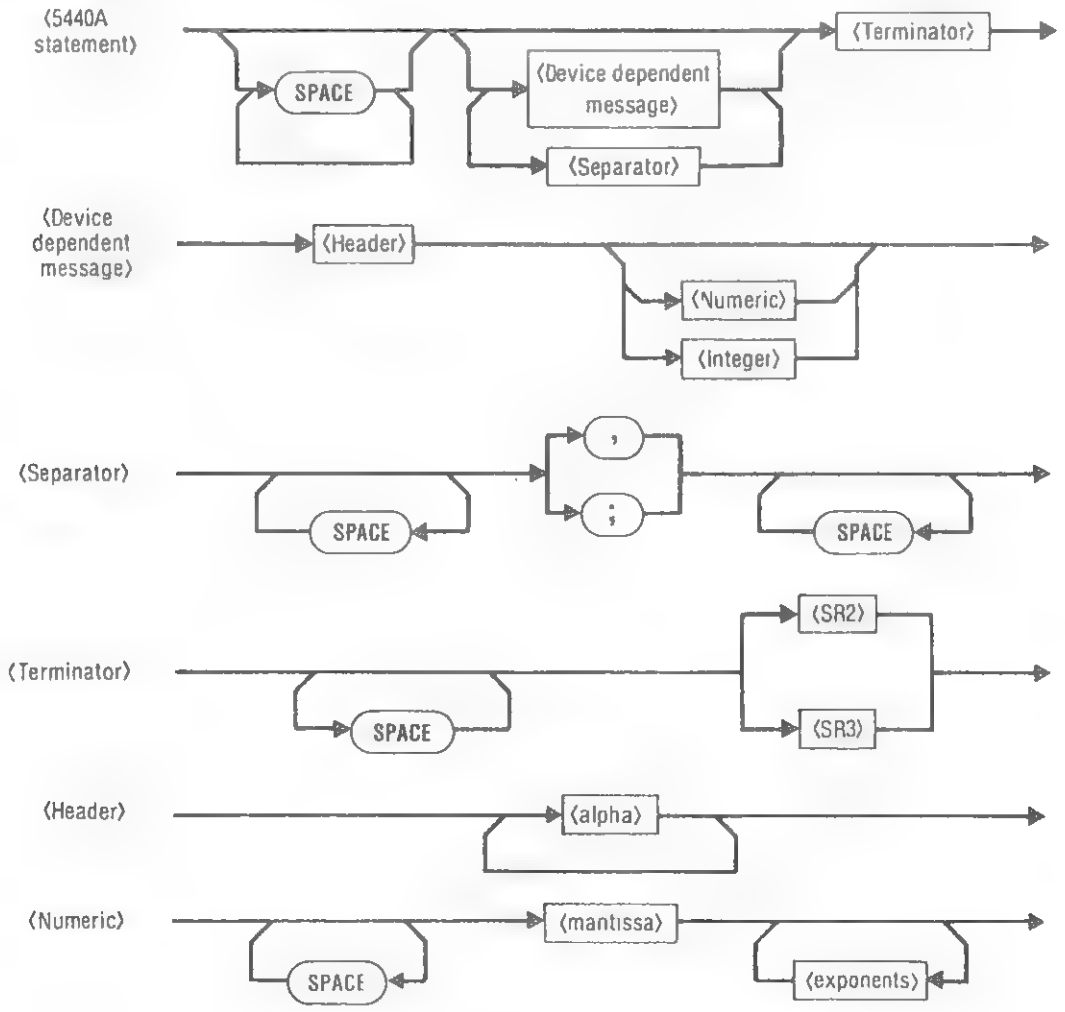


Figure 4-2. 5440A Statement Syntax

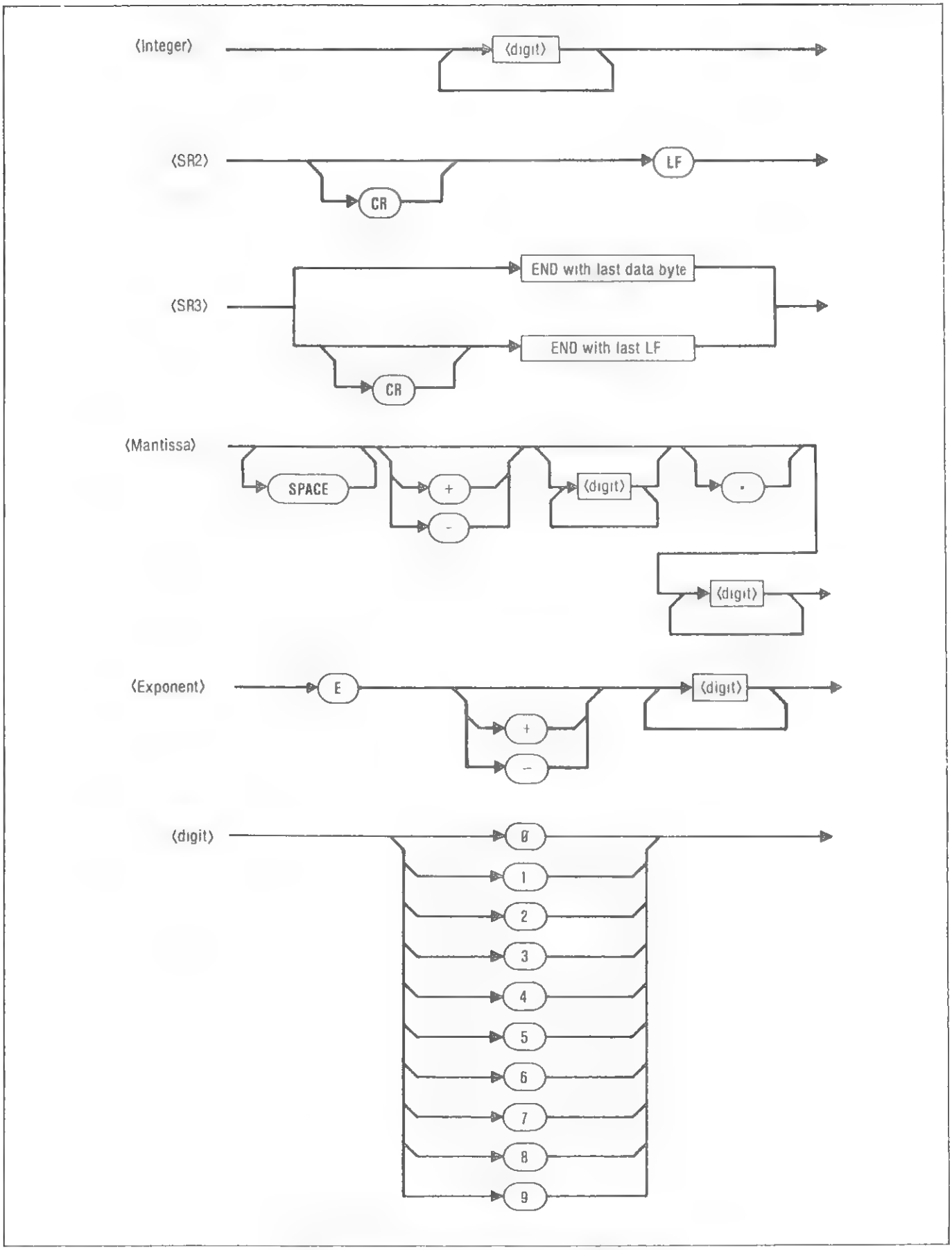


Figure 4-2. 5440A Statement Syntax (cont)

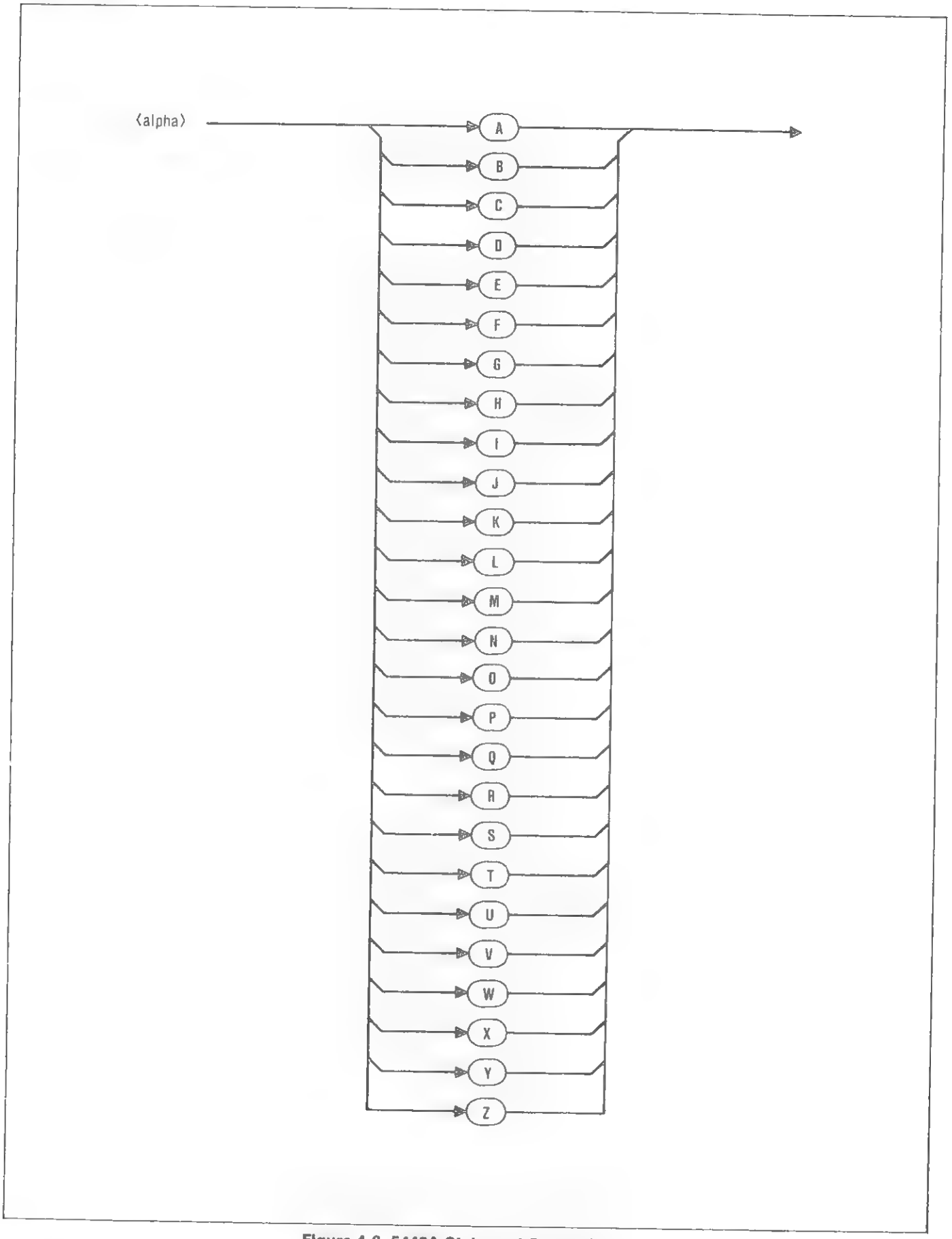


Figure 4-2. 5440A Statement Syntax (cont)

4-30. An exception to rule #1 causes the Input Buffer to clear when the maximum character limit is reached. Any exception to the remainder of the rules causes the entire statement to be ignored.

4-31. Message Sequence

4-32. The sequence in which messages are arranged within 5440A statements is unimportant, but the messages contained in a statement or the sequence of statements can be important to specific applications.

4-33. To understand this statement, let's look at the general structure of 5440A software. As Figure 4-3 shows, the 5440A software can be viewed from the IEEE-488 interface as having a foreground and a background loop with the Setup Status Byte in between. Messages received and sent via the IEEE-488 interface are processed by the foreground loop. Processing takes the same amount of time for every message received. 5440A setup data, such as output, is written on the Setup Status Byte immediately.

4-34. When the background loop sees that the setup status byte has changed, it begins to alter the 5440A hardware. Meanwhile, the foreground loop continues to communicate with the IEEE-488 interface. Some operations take the background loop a relatively long time to complete. For example, the background loop requires on the order of 10 seconds to change the output level from +1100V to -1100V.

4-35. To repeat the original statement, the sequence in which messages are arranged within 5440A statements is unimportant (since the foreground loop processes all messages at the same rate), but the messages contained in a statement or the sequence of statements can be important to specific applications. For example, when the 5440A output is driven above +22V or below -22V, the 5440A is set to Standby as a high voltage safety precaution. So, include and Operate (OPER) message in the same statement with the Set Output (SOUT) message or send an OPER in a statement following the SOUT message.

4-36. DEVICE DEPENDENT MESSAGES

4-37. Introduction

4-38. The device dependent messages duplicate the function of all 5440A front panel controls and report the status of the 5440A on the IEEE-488 compatible interface. Each message is described in the table at the end of this section.

4-39. The device dependent messages can be divided into two categories: those messages that request a response and those that command a certain action by the 5440A (such as Set Output). Responses occur in the same order in which the requests were ordered. The following paragraphs provide general information about responses and specific information about the Setup Status Report, the Long Term Operation Report, the Remote Error Report, and the SRQ and Serial Poll operations.

4-40. Response Messages

4-41. The 5440A sends a message in response to a query message. All response are sent in the same order in which the queries were received. Figure 4-4 shows the syntax of 5440A response messages. Table 4-4 lists the specific responses to all 5440A query messages. The following rules apply for 5440A response messages:

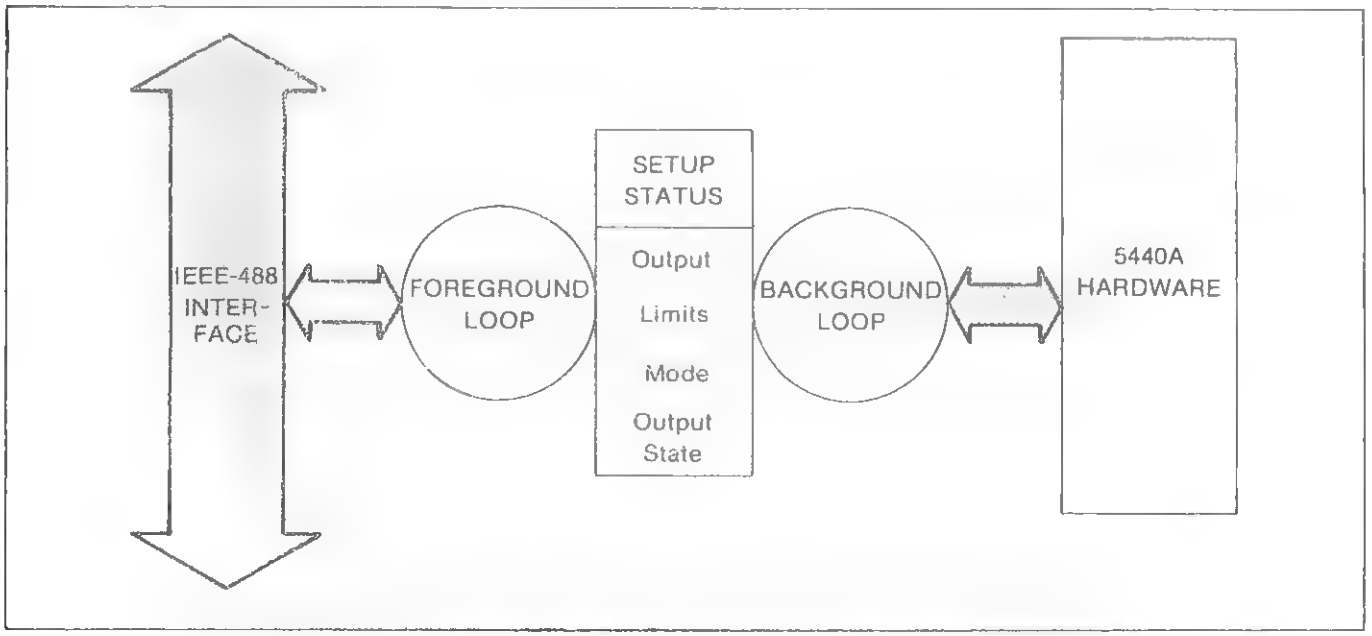


Figure 4-3. 5440A Software Viewed From the IEEE-488 Interface

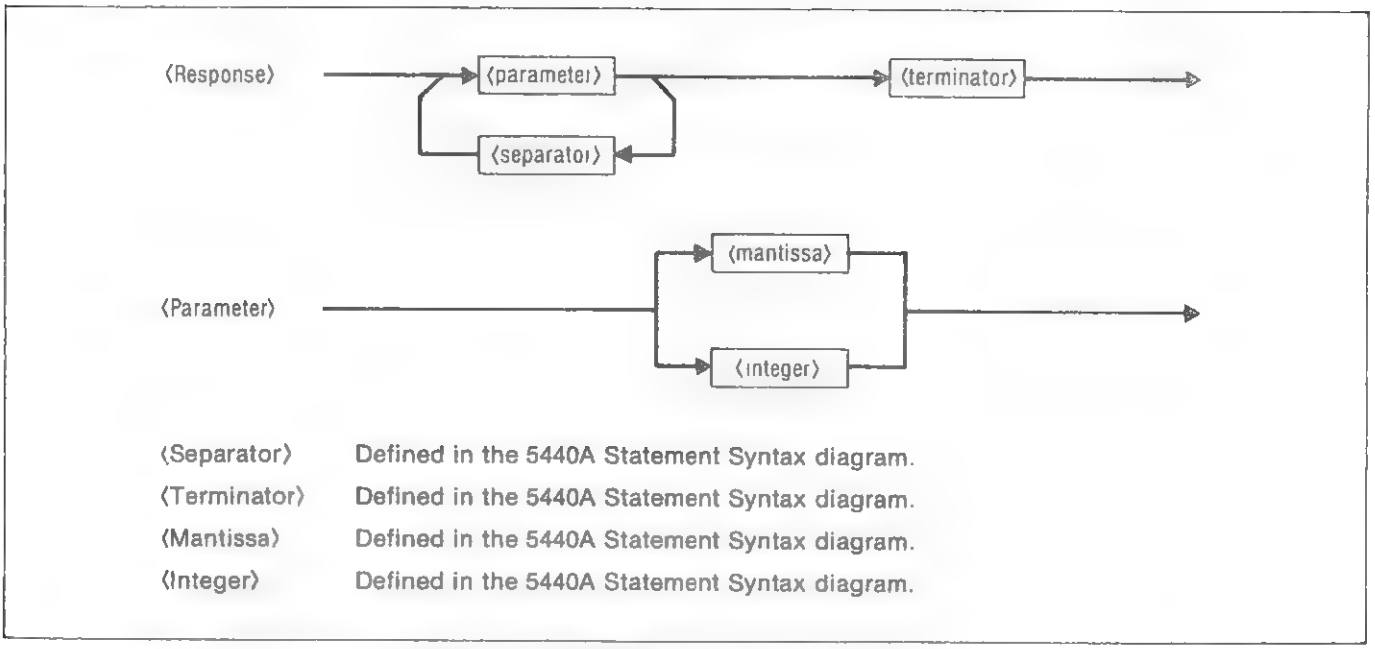


Figure 4-4. 5440A Response Message Syntax

Table 4-4. Responses to 5440A Request Messages

REQUEST MESSAGE	RESPONSE MESSAGE STRUCTURE
GBDR	⟨integer⟩
GCAL	⟨mantissa⟩
GCLM	
Voltage Mode	⟨mantissa⟩
Voltage Boost Mode	not allowed
Current Boost Mode	⟨mantissa⟩ ⟨separator⟩ ⟨mantissa⟩
GDNG	⟨integer⟩
GEPF	⟨integer⟩
GERR	⟨mantissa⟩
GFLR	⟨mantissa⟩
GOUT	⟨mantissa⟩
GPCT	⟨mantissa⟩
GPRF	⟨mantissa⟩
GSEP	⟨integer⟩
GSPB	⟨integer⟩
GSRQ	⟨integer⟩
GSTS	⟨integer⟩
GTRM	⟨integer⟩
GVLM	
Voltage Mode	⟨mantissa⟩ ⟨separator⟩ ⟨mantissa⟩
Voltage Boost Mode	⟨mantissa⟩ ⟨separator⟩ ⟨mantissa⟩
Current Boost Mode	not allowed
GVRS	⟨mantissa⟩

1. One response is generated for each statement containing queries.

2. One parameter is generated for all request messages except Get Volt Limit (GVLM) and Get Current Limit (GCLM). GCLM can have one or two parameter(s) generated depending upon the number of limits programmed. GVLM always sends two parameters.

3. The separator is set by the Set Separator (SSEP) message to be either a comma (,) or a semicolon (;). The default separator is a comma (,)

4. The terminator is set by the Set Terminator (STRM) message. The default terminator is CR END with the last LF

5. Once a statement with a request message has been received, the 5440A will not execute additional statements until the 5440A has sent the response message on the IEEE-488 interface (which should be input by the controller).

6. A mantissa cannot have more than eight significant digits.

7. Integer values must be less than 256.

4-42. Setup Status Report

4-43. When a Get Status (GSTS) message is received, the 5440A reads the Setup Status Byte and sends the

current 5440A setup as the sum of the following codes in Table 4-5. For example, if the 5440A is in the Voltage Mode using internal sense in Operate, the response would be the number 49 followed by a terminator.

Table 4-5. Setup Status Codes

CODE	CONDITION
1	Voltage Mode*
2	Current Boost Mode*
4	Voltage Boost Mode*
8	Divider on
16	Internal Sense/Not External Sense
32	Operate/Not Standby
64	Internal guard shorted to low
128	Rear Output active
*Mutually exclusive modes	

4-44. Long Term Operation Report

4-45. When the Get Doing (GDNG) message is received, the 5440A sends an integer that indicates which part of what long term operation is being executed. Table 4-6 lists the possible response integers and the corresponding states.

4-46. Remote Error Report

4-47. When any of the errors occur, the 5440A sets the appropriate remote error flag. When any remote error flag is set true (1), the error condition bit of the Serial Poll Status Byte is set true (1). If the error condition bit of the SRQ Mask is also true, then an SRQ interrupt is generated on the IEEE-488 interface. The IEEE-488 interface controller sends a Get Error (GERR) message to read the error condition. When the GERR message is received, the 5440A resets all the remote error flags and sends the error status on the IEEE-488 interface as one to three digits followed by a terminator where the digit(s) is the error code. Section 2 of this manual provides additional information about operator error codes. The Troubleshooting section of the 5440A Service Manual provides additional information about all error codes.

4-48. SRQ and Serial Poll

4-49. INTRODUCTION

4-50. All devices connected to the IEEE-488 bus that have SRQ capability can request service from the interface controller. With the serial poll capability, the controller responds by polling the devices one at a time. Polling causes each device to send the binary equivalent of its Serial Poll Status Byte and to clear the request for service bit of the Serial Poll Status Byte.

4-51. Figure 4-5 shows the Serial Poll Status Byte and the SRQ Mask for the 5440A. Note that one bit position is the request for service and all other bit positions indicate specific events or are not used at all. When one of these events occur, the corresponding bit position in the Serial Poll Status Byte is set true (1). If the same bit position is true (1) in the SRQ Mask, then the Request For Service bit position in the Serial Poll Status Byte is set true (1) which requests service by the controller. If the bit position in the SRQ Mask for that event is false (0), then the Request For Service bit position is not affected by the event. For example, bit position 32 of the SRQ Mask must be true (1) for the 5440A to be able to generate an SRQ interrupt when an error condition occurs.

4-52. THE SERIAL POLL STATUS BYTE

4-53. The following paragraphs provide information about each bit position of the Serial Poll Status Byte (Figure 4-5) that is used. The controller can look at the Serial Poll Status Byte by either serial polling or by sending the Get Serial Poll Byte (GSPB) message. The 5440A returns the decimal equivalent of the Serial Poll Status Byte.

4-54. The Request For Service bit requests service from the controller when set true (1). The bit is reset (0) by a serial poll.

4-55. The error condition bit is set true (1) to indicate that an error condition has occurred. The bit position is set false (0) when the controller uses the Get Error (GERR) message to read the error condition. A request for service (RSV) is generated on transition from the no error condition to the error condition. The error message can be interpreted using the information in the Error Status Reporting Format.

4-56. The output settled bit is set true (1) when the 5440A output settles within ± 5%. The bit is set false (0) when the 5440A output is changing, but it is the transition to true that causes the SQR interrupt. To correctly use this feature, prepare the system in advance to wait for the SRQ interrupt.

NOTE

An SRQ is only generated when the output changes. For example, if the output is set at 1V and the user sends 1V over the IEEE-488 interface, no SRQ is generated.

4-57. The message ready to send bit is set true (1) when the 5440A is ready to send a message in reponse to a query message from the IEEE-488 interface. The bit is set false (0) when the message is sent. If another message is waiting to be sent, the bit is immediately set true (1) and the Request For Service bit is set true (1). This insures that there is a separate SRQ for each message waiting to be sent.

4-58. The doing state change bit is set true (1) whenever the 5440A changes its present doing state. A doing state is part of a long term operation such as an internal

calibration. The bit is set false (0) when the IEEE-488 interface controller sends the Get Doing (GDNG) message and a Request for Service is generated on the transition from a zero to a one.

4-59. THE SRQ MASK

4-60. In order for a bit position of the Serial Poll Status Byte to affect the Request for Service bit (and thereby request service from the IEEE-488 interface controller), the corresponding bit position of the SRQ Mask must be true (1). For example, bit position 32 of the SRQ Mask must be true (1) for the 5440A to be able to generate an SRQ interrupt when an error condition occurs. The bit positions of the SRQ Mask can all be set false (0) or be individually set true (1) using the Set Service Request (SSRQ) message.

4-61. Device Dependent Message Summary Table

4-62. Table 4-7 lists and defines all the 5440A device dependent messages.

Table 4-6. Long Term Operation State Codes

CODE	STATE
0	Idle, no state active.
16	Internal calibration, calibrating the Analog to Digital Converter.
32	Internal calibration, zeroing the +10V range.
33	Internal calibration, zeroing the -10V range.
34	Internal calibration, zeroing the +20V range.
35	Internal calibration, zeroing the -20V range.
36	Internal calibration, zeroing the +250V range.
37	Internal calibration, zeroing the -250V range.
38	Internal calibration, zeroing the +1000V range.
39	Internal calibration, zeroing the -1000V range.
48	Internal calibration, gain shift measurement +10V.
49	Internal calibration, gain shift measurement +20V.
50	Internal calibration, gain shift measurement +high voltage.
51	Internal calibration, gain shift measurement -high voltage.
52	Internal calibration, gain shift measurement -20V.
53	Internal calibration, gain shift measurement -10V.
64	External calibration, 10V standard entry. Entry of standard voltage or skip to next range expected.
65	External calibration, 20V standard entry Entry of standard voltage or skip to next range expected.
66	External calibration, 250V standard entry. Entry of standard voltage or skip to next range expected.
67	External calibration, 1000V standard entry. Entry of standard voltage or skip to next range expected.
68	External calibration, 2V divider standard entry. Entry of standard voltage or skip to next range expected
69	External calibration, 0 2V divider standard entry Entry of standard voltage or skip to next range expected.
80	External calibration, 10V null Increment output, skip to next range, or null expected.
81	External calibration, 20V null. Increment output, skip to next range, or null expected.
82	External calibration, 250V null. Increment output, skip to next range, or null expected.
83	External calibration, 1000V null. Increment output, skip to next range, or null expected
84	External calibration, 2V divider null. Increment output, skip to next range, or null expected.
85	External calibration, 0.2V divider null. Increment output, skip to next range, or null expected
96	Internal calibration, measuring the n1/n2 ratio.
112	Digital self test, main microprocessor.
113	Digital self test, front panel microprocessor.
114	Digital self test, guard microprocessor.
128	Analog self test, low voltage.
129	Analog self test, high voltage.
130	Analog self test, oven testing
208	Printing to the printer.
224	Writing to the non-volatile memory.
240	Resetting.

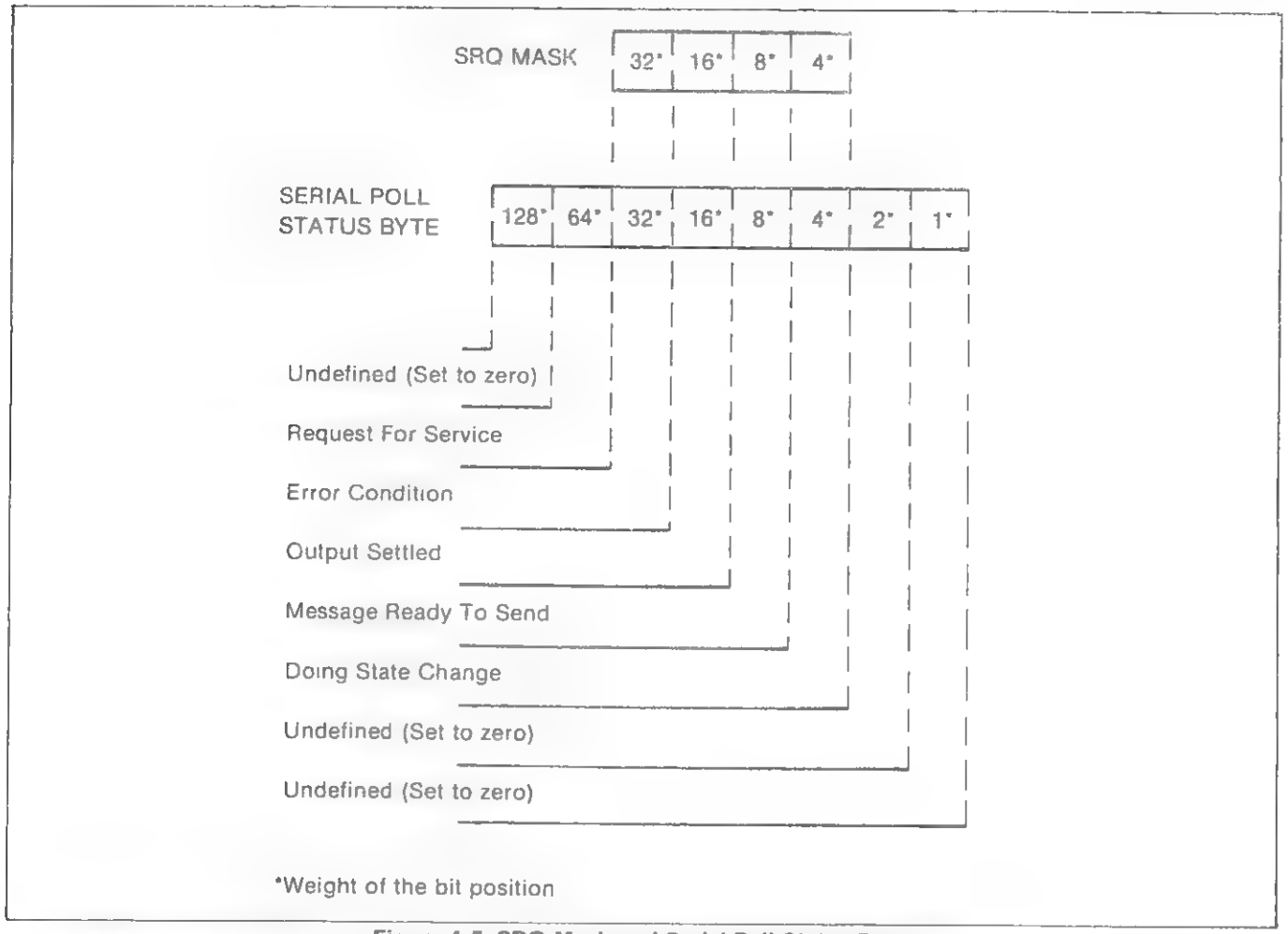


Figure 4-5. SRQ Mask and Serial Poll Status Byte

Table 4-7. 5440A Device Dependent Messages

MESSAGE	COMMENT
RESET RESET	The statement being executed is aborted and the 5440A enters the state described for the RESET key in Section 3.
SET SEPARATOR AND TERMINATOR Set Separator SSEP ⟨integer⟩	Have the 5440A recognize the ASCII character(s) defined by the ⟨numeric⟩ as symbols that separate device dependent messages in 5440A statements. The default separator is a comma (,). The ⟨numeric⟩ can be one of two digits: 0 = , 1 = ,
Get Separator GSEP	Have the 5440A send the selected terminator on the IEEE-488 interface.
Set Terminator STRM ⟨integer⟩	Terminate messages sent from the 5440A with the terminator symbol defined by the ⟨numeric⟩ as follows (CR ⟨END occurred with the last LF⟩ is the default terminator): 0 = ⟨END occurred with the last data byte⟩ 1 = CR ⟨END occurred with the last LF⟩ 2 = ⟨END occurred with the last LF⟩ 3 = CR LF 4 = LF
Get Terminator GTRM	Have the 5440A send the selected terminator on the IEEE-488 interface

Table 4-7. 5440A Device Dependent Messages (cont)

MESSAGE	COMMENT
MODE SELECTION	
Boost Current BSTC	Same as pressing the BOOST (DATA ENTRY) key and the CURR BOOST soft key: enable Current Boost operation. Disable Voltage Boost Mode and Voltage Mode operation.
Boost Current BSTV	Same as pressing the BOOST (DATA ENTRY) key and the VOLT BOOST soft key: enable Voltage Boost operation. Disable Current Boost and Voltage Mode operation.
Boost Off BSTO	Disable boost operation. Enable Voltage Mode operation.
OUTPUT	
Set Output SOUT ⟨numeric⟩	Set the 5440A output to the value of ⟨numeric⟩. The units are amps in Current Boost Mode and volts in both Voltage Mode and Voltage Boost Mode. SOUT does not set the reference. To set the reference use SOUT ⟨numeric⟩ followed by SREF
Get Output GOUT	Have the 5440A send the output value on the IEEE-488 interface.
Increment Output INCR ⟨numeric⟩	Add the ⟨numeric⟩ to the output value.
Set Reference SREF	Store the current output as the error mode reference.
Get Reference GREF	Set the 5440A output to the error mode reference.
OUTPUT STATE	
Operate OPER	Same as pressing the OPR/STANDBY (OUTPUT STATE) key so that it is lit. the output of the 5440A is available at the appropriate terminals.
Standby STBY	Same as pressing the OPR/STBY (OUTPUT STATE) key so that it is not lit: the output of the 5440A is removed from the output terminals.
External Sense ESNS	Same as using the SENSE (OUTPUT STATE) key so that it is lit: the 5440A uses the external sensing circuit.
Internal Sense ISNS	Same as pressing the SENSE (OUTPUT STATE) key so that is not lit: the 5440A uses the internal sense circuit
External Guard EGRD	Same as pressing the GUARD (OUTPUT STATE) key so that it is lit: the 5440A uses the external guard circuit.
Internal Guard IGRD	Same as pressing the GUARD (OUTPUT STATE) key so that it is not lit: the 5440A uses the internal guard circuit.
Enable Divider DIVY	Turn on the output divider.
Disable Divider DIVN	Turn off the output divider.
LIMIT	
Set Voltage Limit SVLM ⟨numeric⟩	Same as pressing the LIMIT (DATA ENTRY) key then the VOLT LIMITS soft key the voltage limit is set to the value of the numeric . During Voltage Mode or Voltage Boost Mode operation, one entry is made to set the positive voltage limit and one entry is made to set the negative voltage limit. The polarity of ⟨numeric⟩ determines which limit is set. Set Voltage Limits is not recognized during Current Boost Mode operation.

Table 4-7. 5440A Device Dependent Messages (cont)

MESSAGE	COMMENT
LIMIT (cont)	
Get Voltage Limit GVLM	Have the 5440A send the voltage limit(s) on the IEEE-488 interface.
Set Current Limit SCLM ⟨numeric⟩	Same as pressing the LIMIT (DATA ENTRY) key then the CURR LIMTS soft key: the current limit is set to the value of the ⟨numeric⟩. During Voltage Mode operation, the current limit is a current trip specification which is the absolute value of the ⟨numeric⟩. During Current Boost Mode operation, one entry is made to set the positive limit and one entry is made to set the negative entry. The polarity of ⟨numeric⟩ determines which limit is set. Set Current Limits is not recognized during Voltage Boost Mode operation.
Get Current Limit GCLM	Have the 5440A send the current limit(s) on the IEEE-488 interface
ERROR	
Set Tolerance Floor SFLR ⟨numeric⟩	Same as pressing the ERROR MODE (DATA ENTRY) then the ENTER TOL soft key: the tolerance floor is set to the fractional value of the ⟨numeric⟩
Get Tolerance Floor GFLR	Have the 5440A send the tolerance floor on the IEEE-488 interface.
Set Percent of Reference SPRF ⟨numeric⟩	The percentage of error specification is set to the value of ⟨numeric⟩
Get Percent of Reference GPRF	Have the 5440A send the percent of reference on the IEEE-488 interface.
Get Percent Error GPCT	Have the 5440A send the calculated percent error of the 5440A output from the reference on the IEEE-488 interface as a fraction.
STATUS AND ERROR REPORTING (see the Report Format material)	
Get Status GSTS	Have the 5440A send the setup status on the IEEE-488 interface in the Setup Status Report Format.
Get Error GERR	Have the 5440A send the error status on the IEEE-488 interface. See Section 2 for additional error code information
Get Version GVRS	Have the 5440A send the version number of the 5440A software on the IEEE-488 interface. The version number is sent in the format dd.dd where dd.dd is the software version number.
Get Doing State GDNG	Have the 5440A report what it's doing during long operations A long operation is any operation that takes more than 5 seconds.
Get % Error Pass/Fail GEPF	Have the 5440A send the % Error Pass/Fail on the IEEE-488 interface as a 1 for pass and a 0 for fail.

Table 4-7. 5440A Device Dependent Messages (cont)

MESSAGE	COMMENT
CALIBRATION Calibration Internal CALI	Start the Internal Calibration Procedure described in the 5440A Service Manual.
Calibration External CALE	Start the Internal Calibration Procedure described in the 5440A Service Manual.
Calibration Standard CSTD (numeric)	The calibration standard voltage for the external calibration is the value of (numeric).
Calibrator Nulled CNUL	The calibrator is nulled with the external voltage standard.
Calibration Skip Range CSKP	Skip the present external calibration range.
Get Calibration Constant GCAL (integer)	Have the 5440A send the calibration constant identified by the (numeric) on the IEEE-488 interface
SELF TESTS Test Analog TSTA	Execute the Analog Self-test. If the test fails, the 5440A generates an error code on the IEEE-488 interface. If the test passes, there is no response. [The result returned by the GDNG (Get Doing State) query at the completion of the self test will be instrument idle.]
Test Digital TSTD	Execute the Digital Self-test. If the test fails, the 5440A generates an error code on the IEEE-488 interface. If the test passes, there is no response. [The result returned by the GDNG (Get Doing State) query at the completion of the self test will be instrument idle.]
Test High Voltage TSTH	**WARNING** **TO AVOID SHOCK HAZARD DURING THE HIGH VOLTAGE SELF TEST, NEVER MAKE ELECTRICAL CONTACT WITH THE OUTPUT HI OR SENSE HI TERMINALS OF THE 5440A.** Execute the High Voltage Self-test. If the test fails, the 5440A generates an error code on the IEEE-488 interface If the test passes, there is no response. [The result returned by the GDNG (Get Doing State) query at the completion of the self test Will be instrument idle.]
BAUD RATE Set Baud Rate SBDR (integer)	Set the 5440A baud rate to the value of the integer where the integer can be any decimal number from 0 through 12: INTEGER / BAUD RATE / INTEGER / BAUD RATE 0 / 50 / 7 / 600 1 / 75 / 8 / 1200 2 / 110 / 9 / 1800 3 / 134.5 / 10 / 2400 4 / 150 / 11 / 4800 5 / 200 / 12 / 9600 6 / 300
Get Baud Rate GBDR	Send the 5440A baud rate on the IEEE-488 interface
MONITOR Monitor Yes MONY	Turn the RS-232-C monitor on. All internal calibration and analog test data is sent out on the RS-232-C interface.
Monitor No MONN	Turn the RS-232-C monitor off.

Table 4-7. 5440A Device Dependent Messages (cont)

MESSAGE	COMMENT
SERVICE REQUEST Set Service Request SSRQ ⟨integer⟩	Set the positions in the SRQ Mask (see the SRQ and Serial Poll material in this section) to generate an interrupt on the conditions defined by the ⟨integer⟩ The ⟨integer⟩ is the sum of the following codes (the default value is 0): 0 = Never generate an interrupt 4 = Interrupt doing a long term operation (5 seconds or longer). 8 = Interrupt when the requested message is ready to send. 16 = Interrupt when the output is settled 32 = Interrupt when there is an error condition.
Recall Service Request GSRQ	Have the 5440A send the SRQ Mask on the IEEE-488 interface.
Get Serial Poll Status Byte GSPB	Have the 5440A send the decimal equivalent of Serial Poll Status Byte. Also see the SRQ and Serial Poll material in this section

Section 5
Printer Output Via the RS-232-C Interface

5-1. INTRODUCTION

5-2. The information in this section describes specific information about the 5440A RS-232-C interface. The RS-232-C interface is designed in accordance with the EIA standard RS-232-C to allow the 5440A calibration and test results to be printed and to allow 5440A test programs to be viewed on a remote video monitor.

5-3. 5440A RS-232-C INTERFACE INFORMATION

5-4. Introduction

5-5. The following paragraphs provide specific information about the RS-232-C interface as implemented in the 5440A. This information should be read and thoroughly understood before attempting to operate the 5440A.

5-6. 5400A RS-232-C Interface Specifications

5-7. Table 5-1 lists the RS-232-C specifications of the 5440A.

5-8. Interface Connection

5-9. The RS-232-C port connector on the rear panel of the 5440A is described in Section 2. Interconnect cable accessories are described in Section 7. Figure 2-4 shows the physical relationship between the 5440 serial interface, the shorting plug, and the RS-232-C connector.

5-10. Baud Rate Selection

5-11. Baud rate is factory set to 2400. To set baud rate press the SVCE (DATA ENTRY) key then the PORT SERV soft key then the RS232 BAUD soft key then enter the baud rate using the DATA ENTRY keys. Baud rate can be set to 50, 75, 110, 134, 150, 200, 300, 600, 1200, 1800, 2400, 4800, or 9600 baud.

5-12. RS-232-C OPERATION

5-13. Once the printer or monitor is properly connected to the 5440A (including setting baud rate), the 5440A sends data to the peripheral device. Sections 3 and 4 describe front panel and IEEE-488 operations that affect the type of data sent on the RS-232-C interface. Figures 5-1 through 5-5 show example printouts:

- Figure 5-1 shows an example Calibration Constant Listing.
- Figure 5-2 shows an example Sequence Listing.
- Figure 5-3 shows an example Results Listing.
- Figure 5-4 shows an example Internal Calibration Monitor Listing.
- Figure 5-5 shows an example Analog Diagnostics Monitor Listing

Table 5-1. RS-232-C Specifications

FUNCTION	COMMENTS
Signal Configuration	Modem, full duplex
Serial Output	Pin 3 on the rear panel RS-232-C connector
Serial Input	Pin 2 on the rear panel RS-232-C connector
Data Terminal Ready (DTR-handshake line)	Pin 20 on the rear panel RS-232-C connector DTR-handshake line must be set true in order for the 5440A to transmit serial information. At present this is accomplished by tying DTR to DSR on the shorting plug located on the rear panel. The DTR signal may be also used as a "ready" signal from the user's printer but the user must cut the wire that connects pins 4 and 11 on the shorting plug.
Data Set Ready (DSR-handshake line)	Pin 6 on the rear panel RS-232-C connector The DSR output is used to indicate that the 5440A is connected.
Signal Ground	Pin 7 on the rear panel RS-232-C connector
Chassis (earth ground)	Pin 1 on the rear panel RS-232-C connector The user may change the pin location by rewiring the shorting plug.
Stall and Unstall	Supported. The Stall command (DC3 or 13 HEX) can be sent by the printer to stop the 5440A data output until the Unstall command (DC1 or 11 HEX) is received.

JOHN FLUKE MFG. CO., INC. 5440A CALIBRATION DATA

CONSTANT	10V RANGE	20V RANGE	250V RANGE	1000V RANGE
Gain	+.54313609 mV	+1.0862640 mV	+13.577998 mV	+54.311978 mV
2V Gain		+1.0862762 mV		
.2V Gain		+1.0862863 mV		
+Offset	+4.8645389 mV	+9.7681830 mV	+122.47198 mV	+490.39426 mV
-Offset	+5.5948529 mV	+11.149847 mV	+139.00318 mV	+555.53586 mV
Gain Shift	-.0 PPM	-.0 PPM	-.0 PPM	-.0 PPM

Resolution ratio: 7292 A/D gain: +.2813 mV

Figure 5-1. Example Calibration Constant Listings

```
JOHN FLUKE MFG. CO., INC.                                  5440A SEQUENCE LISTING

DATE_____________________________  OPERATOR_____________________________

STEP     OUTPUT                LIMITS                    STATE
 01   +1.0000000 V  +2.0000000 V -2.0000000 V   STBY   DIV
                    +5.00mA                     TOL SPEC:+.00100%+2.000uV
 02   +12.000000 V  +100.00000 V -100.00000 V   STBY
                    +20.0mA
 03   +13.000000 V  +100.00000 V -100.00000 V   STBY                EXTGRD
                    +20.0mA                     % ERROR ON
 04   +14.000000 V  +1100.0000 V -1100.0000 V   STBY
                    +25.0mA                     TOL SPEC:+.00100%+2.000uV
 05   +15.000000 V  +1100.0000 V -1100.0000 V   STBY        EXTSNS
                    +25.0mA                     TOL SPEC:+.00100%+2.000uV
```

Figure 5-2. Example Sequence Listing

```
JOHN FLUKE MFG. CO., INC.                                  5440A UUT RESULTS

DATE_____________________________  OPERATOR_____________________________
INSTRUMENT_______________________  SERIAL NO._____________

STEP     OUTPUT       REFERENCE      TOLERANCE SPEC     % ERROR
 01   +1.0000012 V  +1.0000000 V   +.00100%+2.000uV   -1.2000PPM
 02   +12.000200 V  +12.000000 V
 03   +13.000030 V  +13.000000 V                      -2.3000PPM
 04   +14.022340 V  +14.000000 V   +.00100%+2.000uV   -.15957%     FAIL
 05   +15.005000 V  +15.000000 V   +.00100%+2.000uV   -333.30PPM   FAIL
```

Figure 5-3. Example Results Listing

```
JOHN FLUKE MFG. CO., INC.                          5440A INTERNAL CALIBRATION

+10V ZERO
     1: N1=  7, N2=14250, Offset    -1.2uV
     2: N1=  7, N2=14266, Offset     -.3uV

RESOLUTION RATIO
     1: N1=  6, N2=21558, Offset     -.1uV

-10V ZERO
     1: N1=  9, N2= 9500, Offset    -1.0uV
     2: N1=  9, N2= 9487, Offset     -.2uV

+20V ZERO
     1: N1=  7, N2=14529, Offset    -1.5uV

-20V ZERO
     1: N1=  9, N2= 9220, Offset    -1.0uV

+250V ZERO
     1: N1=  7, N2=14729, Offset    -9.1uV

-250V ZERO
     1: N1=  9, N2= 9023, Offset   -12.1uV

+1000V ZERO
     1: N1=  7, N2=14797, Offset   -71.8uV

-1000V ZERO
     1: N1=  9, N2= 8959, Offset   -76.7uV

GAIN SHIFT
     +10:   +376.24uV
     +20:   +442.87uV
     +Hi:   +451.03uV
     -Hi:   -838.11uV
     -20:   -830.32uV
     -10:   -764.04uV

END OF INTERNAL CALIBRATION
```

Figure 5-4. Example Internal Calibration Monitor Listing

```
JOHN FLUKE MFG. CO., INC.                          5440A ANALOG DIAGNOSTICS

      ADM1: +.000000V
      ADM2: -.002264V
      ADM3: +2.50904V
      M1:  +13.0956V
      M1:  +13.0956V
      M3:  -11.7032V
      M4:  -16.6795V
      C1:  +4.97630V
      M5:  -5.07129V
      M6:  -16.3756V
      M7:  -9.68921V
      C2:  -13.0324V
      M8:  -13.0353V
      C3:  +.002917V
      M9:  -4.80722V
      M10: -1.53899V
      C4:  -3.17311V
      M11: -3.17305V
      C3:  -.000056V
      M12: -16.0257V
      M13: -17.2470V
      C5:  +1.22133V
      M14: -9.98358V
      M15: +9.90975V
      M16: -.036913V
      M17: -.000281V
      M18: -.001688V
      C6:  +.001407V
      M19: -.000281V
      M20: -.001810V
      C7:  +.001529V
      M21: +.000370V
      M22: +.000436V
      M23: -.000070V
      M24: -.000075V
      M25: +.004902V
      M26: +9.97560V
      M27: +19.9601V
      M28: -9.97560V
      M29: +.000000V
      M30: +19.8841V
      M31: -.120445V
      M32: +19.8841V
      M33: +.000445V
      M34: +19.9601V
      M35: +19.8615V
      M36: +22.2283V
      M37: -.312370V
      M38: +.050936V
      M39: +.822152V
      M40: +.828765V
      C8:  -.006613V

END OF ANALOG DIAGNOSTICS
```

Figure 5-5. Example Analog Diagnostics Monitor Listing

Section 6
Theory of Operation

6-1. INTRODUCTION

6-2. The information in this section describes the 5440A theory of operation at a functional overview level that supports the Module Exchange Program. The descriptions are broken into three parts: the Hardware Functional Overview, the Software Functional Overview, and the 5440A Internal Calibration.

6-3. HARDWARE FUNCTIONAL OVERVIEW

6-4. As Figure 6-1 shows, the 5440A is composed of three types of circuits: power supply, analog, and digital. The power supply circuits generate and control all operating voltages for the 5440A. A guard circuit isolates the analog and digital circuits from one another. The analog circuits generate and control the 5440A output. The digital circuits control the analog circuits and provide input and output via the front panel, the IEEE-488 interface, and the RS-232-C port.

6-5. Digital Circuits

6-6. As Figure 6-2 shows, the digital circuits are controlled by three microprocessors. Use of these microprocessors divides the digital circuits into three areas. main control logic, front panel control logic, and guarded control logic. The main logic is the central controller of the 5440A which indirectly controls the analog circuits through the guarded control logic, communicates with local users through the front panel control logic, and maintains remote communication via the IEEE-488, RS-232-C and Boost interfaces

6-7. MAIN CONTROL LOGIC

6-8. The main control logic (Figure 6-2) is located outside the 5440A guard and contains the central 5440A controller (main microprocessor), main memory, and input/output circuits. The input/output circuits allow the main microprocessor to communicate on the IEEE-488, RS-232-C, and Boost interfaces.

6-9. The main microprocessor generates all control sequences to the guarded control logic. These sequences include instructions for setting the 5440A output to the programmed value and comprehensive self-test and diagnostic procedures.

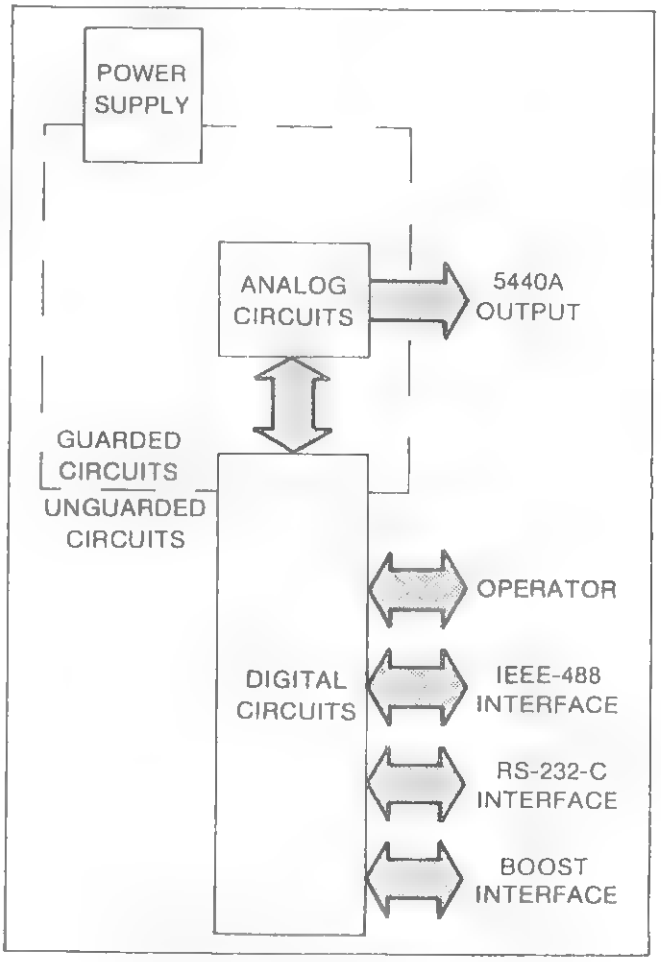


Figure 6-1. 5440A Block Diagram

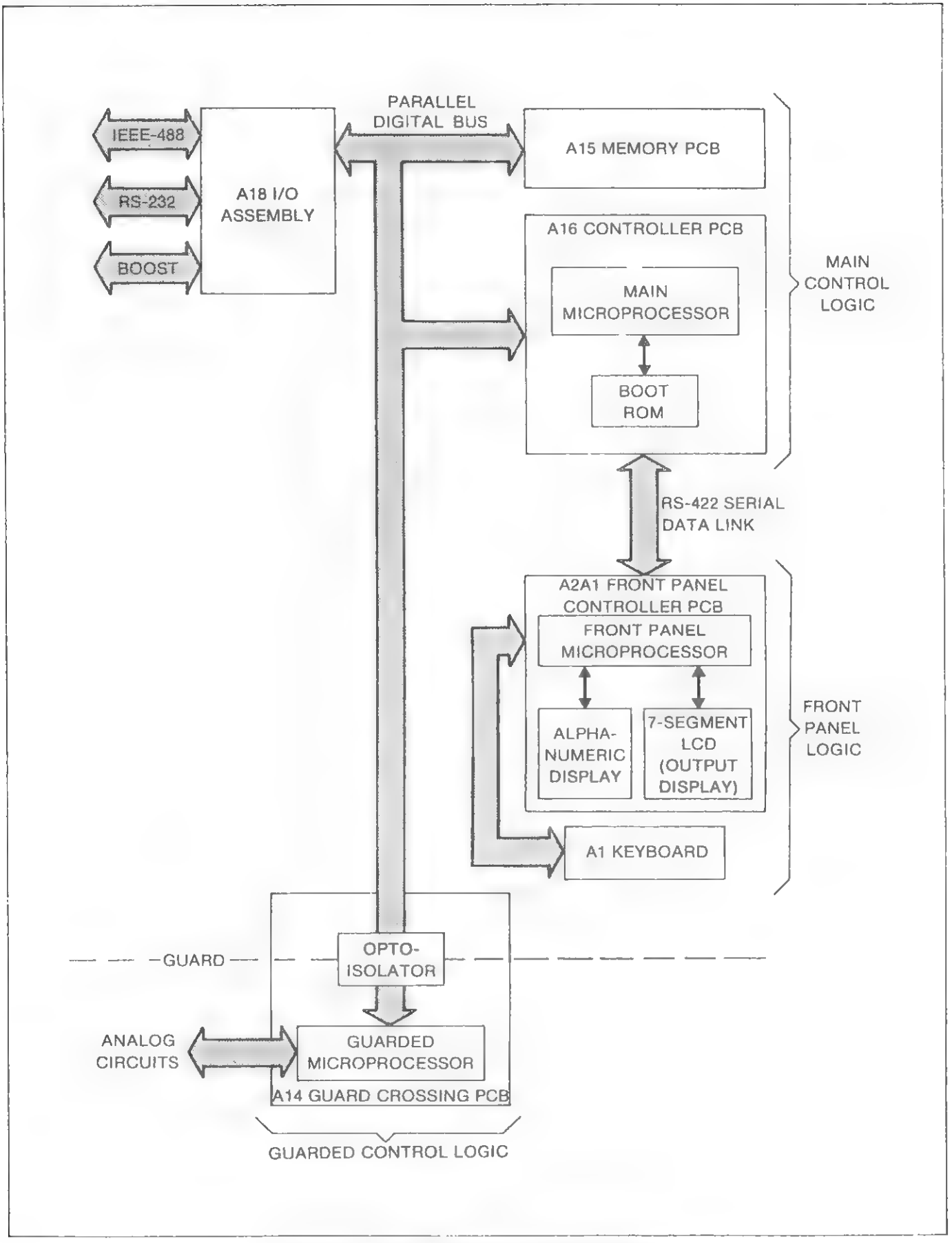


Figure 6-2. 5440A Digital Circuit Block Diagram

6-10. The main microprocessor communicates with remote devices over three interfaces: RS-232-C, Boost, and IEEE-488. The RS-232-C interface is used to output 5440A test and diagnostic data on a printer or monitor. The Boost interface is used to drive and control a 5220A or a 5205A connected to the interface during boost operation.

6-11. The 5440A is designed to be controlled via the IEEE-488 interface. The main microprocessor interprets messages from the external IEEE-488 interface controller and sense the appropriate responses on the IEEE-488 interface.

6-12. The main microprocessor communicates with the front panel microprocessor via a serial data link to perform three main functions: 5440A-7001 Storage Module communication, display functions, and operator interface (local operation).

6-13. During local operation, the main microprocessor interprets key entries from the front panel microprocessor and generates the appropriate response. for example, if a new output is entered at the front panel (and the 5440A is in local operation), the main microprocessor sends the appropriate control sequences to the guarded control logic which drives the analog circuits to produce the programmed output.

6-14. During local and remote operation the main microprocessor uses the front panel microprocessor to store or read front panel setups from the 5440A-7001 Storage Module. The storage module can hold up to 60 complete front panel setups.

6-15. During local operation, the main microprocessor provides self test and diagnostic information to the front panel microprocessor. This information appears in the Alphanumeric Display.

6-16. The main microprocessor controls the Digital and Analog self test and reports the results to the front panel microprocessor for display and on the IEEE-488 interface upon request. Depending upon the setting off the self-test switches (located on the A16 Controller PCB) the main control logic may execute several special self test routines to exercise portions of its logic (described in the 5440A Service Manual).

6-17. When the 5440A has just been tuned on or whenever the 5440A is reset (front panel RESET key or IEEE-488 interface RESET message), the main microprocessor reads the Boot ROM and sets the 5440A up according to the conditions programmed in the ROM. (See Section 3 for the default Power Up setup.)

6-18. FRONT PANEL LOGIC

6-19. The front panel logic is contained on the A2 Front Panel Controller/ Display PCB. The front panel logic is a local input/output area. Inputs are entered via the keyboard. The front panel microprocessor interprets inputs from the keyboard and sends the interpreted messages to the main control logic. In turn, the front panel microprocessor interprets output information from the main control logic and displays the output information in the appropriate display. The front panel microprocessor also stores and recalls front panel setups into the 5440A-7001 Storage Module.

6-20. Depending on the setting of the self-test switches (located on the A2A1 Front Panel Controller PCB), the front panel logic may execute several special self-test routines to exercise portions of its logic (described in the 5440A Service Manual).

6-21. GUARDED CONTROL LOGIC

6-22. The guarded control logic (Figure 6-2) provides optically isolated control of the analog circuits. The main control logic sends all control sequences to the guarded microprocessor through the opto-couplers of the guarded control logic. The main function of the guarded microprocessor is to pass control sequences to the analog circuits. The guarded microprocessor also performs three secondary functions:

1. It provides status information to the main control logic on command.

2. It independently refreshes the analog circuits to improve system operation

3. It continually monitors the guarded circuits to detect fault conditions.

6-23. The guarded logic uses two time-out monitor circuits to ensure safety. If either the main microprocessor or the guarded microprocessor fail to execute their programs correctly, a time-out monitor circuit places the 5440A in Standby. The instrument can only be restarted by pressing the RESET button on the front panel.

6-24. The guarded logic has a one self-test switch. Use of this switch provides limited self-test capability of the guarded logic.

6-25. Analog Circuits

6-26. INTRODUCTION

6-27. The analog circuits establish a stable dc reference voltage and provide precise amplification and attenuation of this reference voltage to produce output voltages from -1100V dc to +1100V dc in six ranges. As Figure 6-3 shows, a 13V reference and a pulse width modulated DAC, on the A9 REF/DAC Analog PCB, produce -11V dc to +11V dc under control of the A8 REF/DAC Digital PCB. The A7 Preamp PCB, the A4 Output PCB, and the A6 Sample String PCB form an inverting amplifier with six digitally controlled gains. The A5 Output/HV Control PCB controls generation of voltages greater than 22V dc by feeding these voltages

(+KV and -KV) back to the A4 Output PCB where they are added in series with the low voltage output. Other important analog circuits include a low resolution analog-to-digital converter and switching circuits. The low resolution analog-to-digital converter is used to monitor various internal and output voltage levels. The switching circuits implement the internal calibration features.

6-28. OVENED REFERENCE

6-29. The ovened reference provides the stable reference voltage for the circuits that generate the 5440A output. The stability of the 5440A output can be no better than the stability of the ovened reference.

6-30. Located on the A9 REF/DAC Analog PCB, the reference is composed of two 6.5 volt hybrid reference amplifiers cascaded in series to produce a summed voltage of 13.0V dc. The amplifier components are selected for low noise, good stability and a low temperature coefficient. The oven maintains the reference amplifier environment at a constant 50o C. Sources of secondary errors have been substantially reduced by eliminating reference voltage adjustments.

6-31. DIGITAL-TO-ANALOG CONVERTER

6-32. The digital-to-analog converter (DAC) is located on the A9 REF/DAC Analog PCB and is controlled by the A8 REF/DAC Digital PCB. The 13V dc reference voltage from the ovened reference is applied through relays to the DAC (Figure 6-4). The relays determine the polarity of the reference voltage which determines the polarity of the DAC output (and, thereby, the polarity of the 5440A output).

6-33. The reference voltage is pulse width modulated by two FET switches, a filter, and an integrating dc amplifier. The first switch is a coarse control and the second switch is a fine control. The outputs of both switches is are summed and filtered by the dc amplifier. (For stability, the dc amplifier is located in the same ovened environment as the 13V reference.) The output of the dc amplifier (the DAC output) equals the pulse duty cycle times the voltage of the precision reference. This output can be programmed from -12V dc to +12V dc. Coarse resolution (from the first switch) is programmed in steps of 0.5 mV. Fine resolution (from the second switch) is programmed in steps of 75 nV.

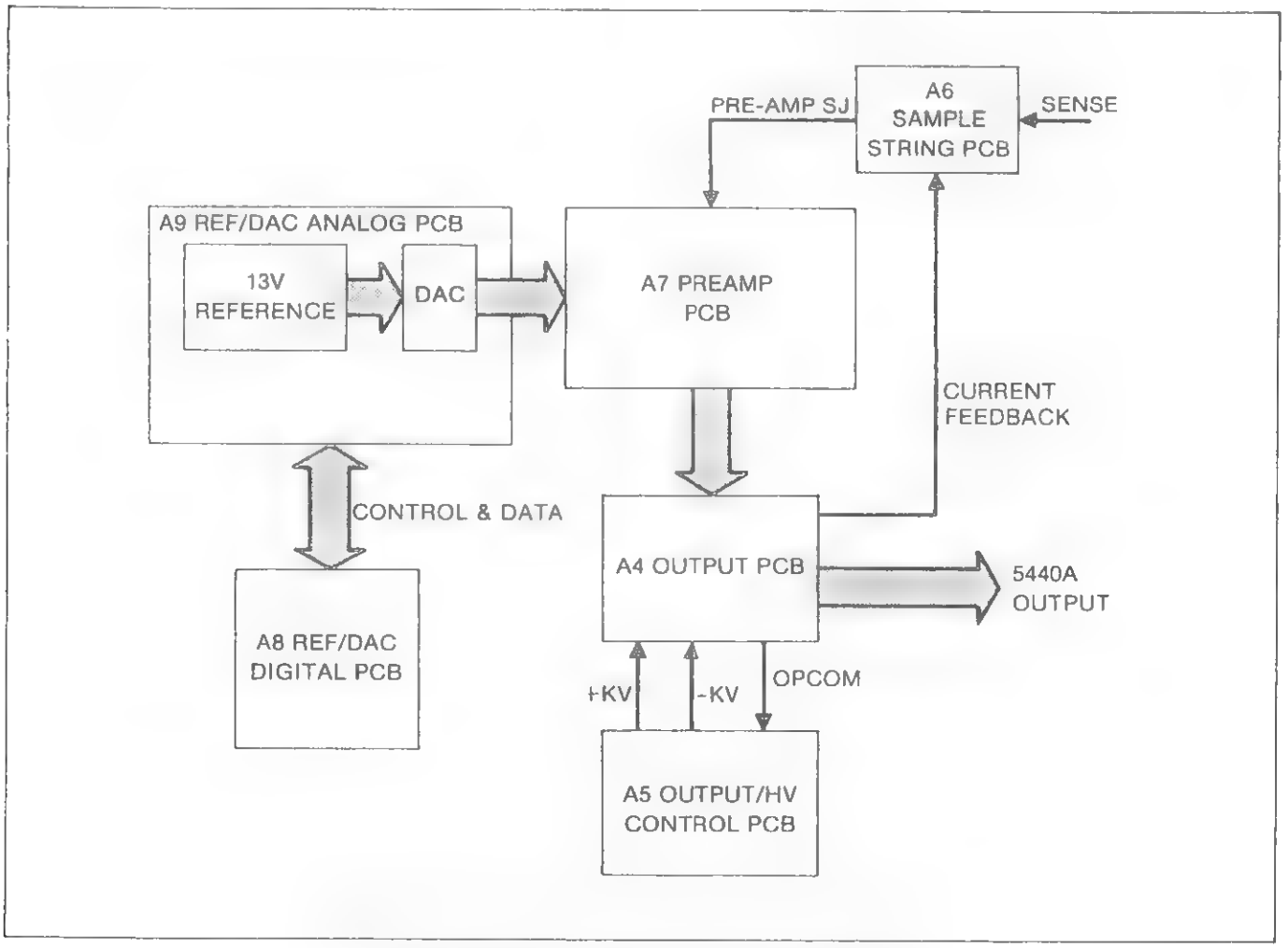


Figure 6-3. 5440A Analog Circuit Block Diagram

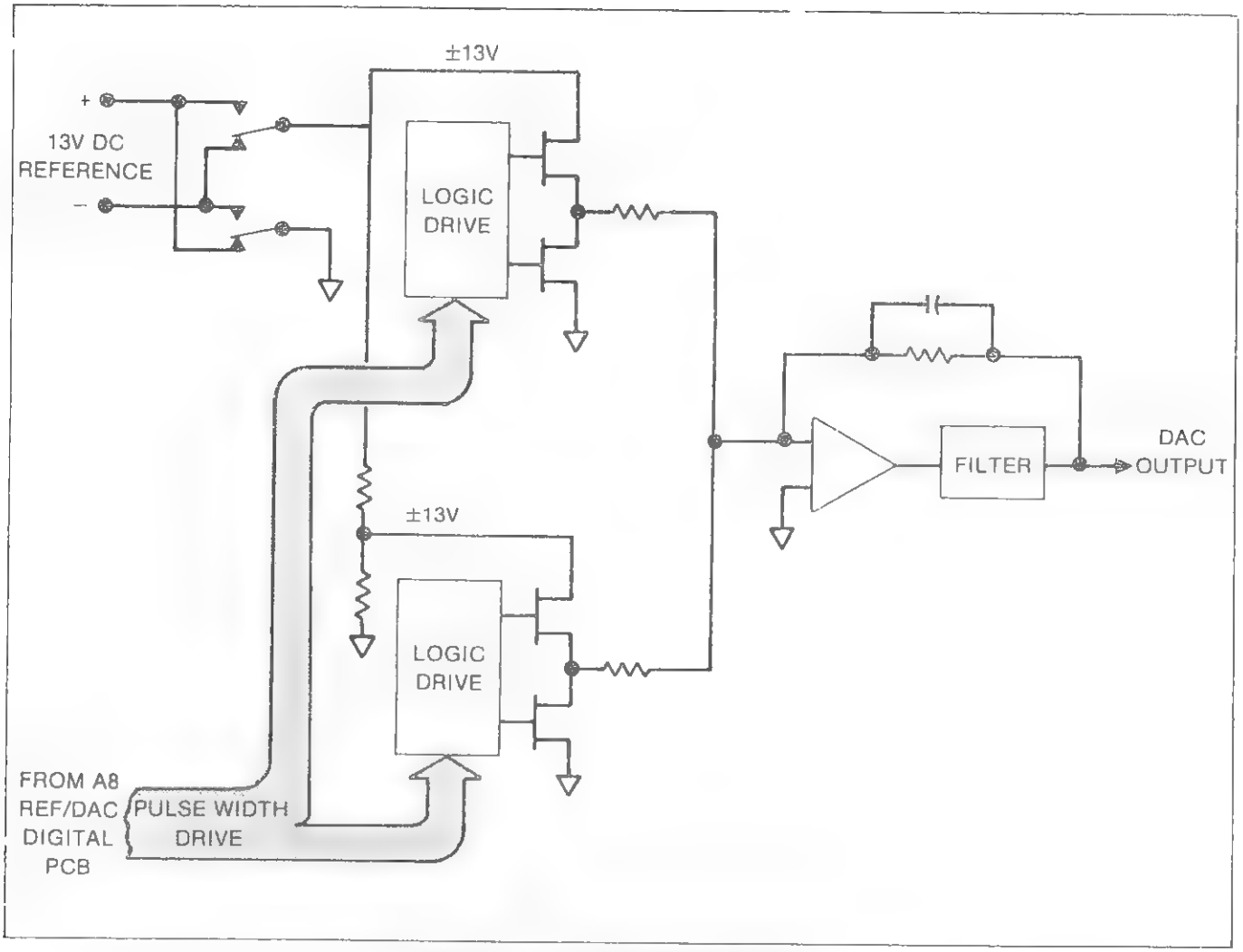


Figure 6-4. DAC Simplified Schematic

6-34. The absolute value of the DAC output is determined by the duty cycle of the pulse width drive signals generated on the A8 REF/DAC Digital PCB. The pulse width drive signals of the two switches are sent to the A8 REF/DAC Digital PCB, via the guarded control logic, from the main control logic as two 16-bit words. These words are generated through an algorithm that uses constants generated and stored by the Internal and External Calibration procedures. There is a set of calibration constants for each of the six 5440A output ranges listed in Table 6-1.

6-35. OUTPUT AMPLIFIER AND DIVIDERS

6-36. As Figure 6-5 shows, the output amplifier and dividers are an output circuit composed of the A7 Preamp PCB, the A4 Output PCB, and the A6 Sample String PCB. The DAC output is amplified in the 5440A output by this loop.

6-37. The A7 Preamp PCB is a high gain amplifier used to control the output circuit for the 11, 22, 275, and 1100 volt ranges. (The 0.2 and 2 volt ranges are divided from the 22 volt range.) The DAC output is amplified and sent to the A4 Output PCB. The preamplifier circuit is located in a temperature controlled oven to reduce the effects of external temperature.

6-38. The output of the A7 Preamp PCB drives the series pass transistors Q1 and Q2 on the A4 Output PCB. The series pass transistors are supplied by a low voltage power supply (–30V dc and +30V dc) for the 11 and 22 volt ranges and by a high voltage power supply (+hv and –hv) for the 250 and 1100 volt ranges. (the high voltage power supply is controlled by the A5 Output/HV Control PCB and the A13 Filter B PCB.) During Voltage Mode operation, the series pass transistor output is relay switched to the output terminals. During either Boost Mode, the series pass transistor output is relay switched to the rear panel Boost Interface connector. During Divider operation, the 5440A is set to the 22 volt range and the output of the series pass transistors is relay switched to a 10:1 divider for the 2 volt range or a 100:1 divider for the 0.2 volt range.

Table 6-1. 5440A Output Ranges

RANGE NAME	OUTPUT VOLTAGE RANGE (V dc)	FUNCTION
0.2 Volt	-0 22 to +0.22	Divider Output
2 Volt	-2.2 to -0.22 and +0.22 to +2.2	
11 Volt	-11 to -2.2 and +2.2 to +11	DC Calibrator Output
22 Volt	-22 to -11 and +11 to +22	
250 Volt	-275 to -22 and +22 to +275	
1100 Volt	-1100 to -275 and +275 to +1100	

6-39. The A6 Sample String PCB contains the precision resistors that set the gain of the output circuit. The gain is set for each 5440A output range by relay switching the value of R2 as listed in Table 6-2. The resistors are contained in an oven which holds the temperature at a constant 55°C to greatly reduce the affect that changes in the ambient temperature would have on their stability.

6-40. OUTPUT SENSING CIRCUIT

6-41. The output sensing circuit is connected on the A4 Output PCB directly to the output for Internal Sense operation or to the SENSE HI and SENSE LO binding posts for External Sense operation. The output sensing circuit is a unique high impedance sense circuit (hZs™). This high impedance sense circuit is a negative impedance converter (INIC) that is designed to produce a compensating current exactly equal in magnitude but opposite in polarity to the current flowing through the feedback resistance (R2) on the A6 Sample String PCB. This compensating current flows through the relay contacts, pcb connectors, and external sense leads back to the OUTPUT HI terminal. This reduces sense currents to less than 1% of the current flowing through the sample string resistors on the A6 Sample String PCB. Another circuit compensates for SENSE LO currents.

6-42. Power Supply and Guard Circuits

6-43. INTRODUCTION

6-44. The power supply and guard circuits transform the line power into the various supply voltages required by the analog and digital circuits. As Figure 6-6 shows, the power supply and guard circuits consist of six modules. The A17 Outside Guard Regulator PCB and the A19 Outside Guard Term PCB supply the analog and digital circuits outside the guard. The A10 Inside Regulator PCB, the A11 Guarded Xfmr Term PCB, the A12 Filter A PCB, and the A13 Filter B PCB supply the analog and digital circuits inside the guard of each sub-assembly.

6-45. A11 GUARDED XFMR TERM PCB

6-46. The Power input to the 5440A is applied to the power supply via the A11 Guarded Xfmr Term PCB. As shown in Figure 6-6, line power is input via line fuse F1 and power switch S4. The Line Voltage Select Switches (S1, S2, and S3) set the primary taps of T1 to the correct input voltage. Power is delivered through transformer T1 to the rest of the guarded power supply circuits. The fan and the primary of the transformer on the A19 Outside Guard Term PCB are permanently connected to taps on one primary of guarded transformer T1. This provides nominal 115V ac by auto-transformer action when the line switched are correctly set.

6-47. Line fuse F1 provides overall fuse protection for the 5440A. Individual secondary windings contain internal fuses that protect the transformer from damage in the event that a short in a secondary circuit does not reflect enough current to the primary winding to blow the line fuse.

6-48. A12 FILTER A PCB

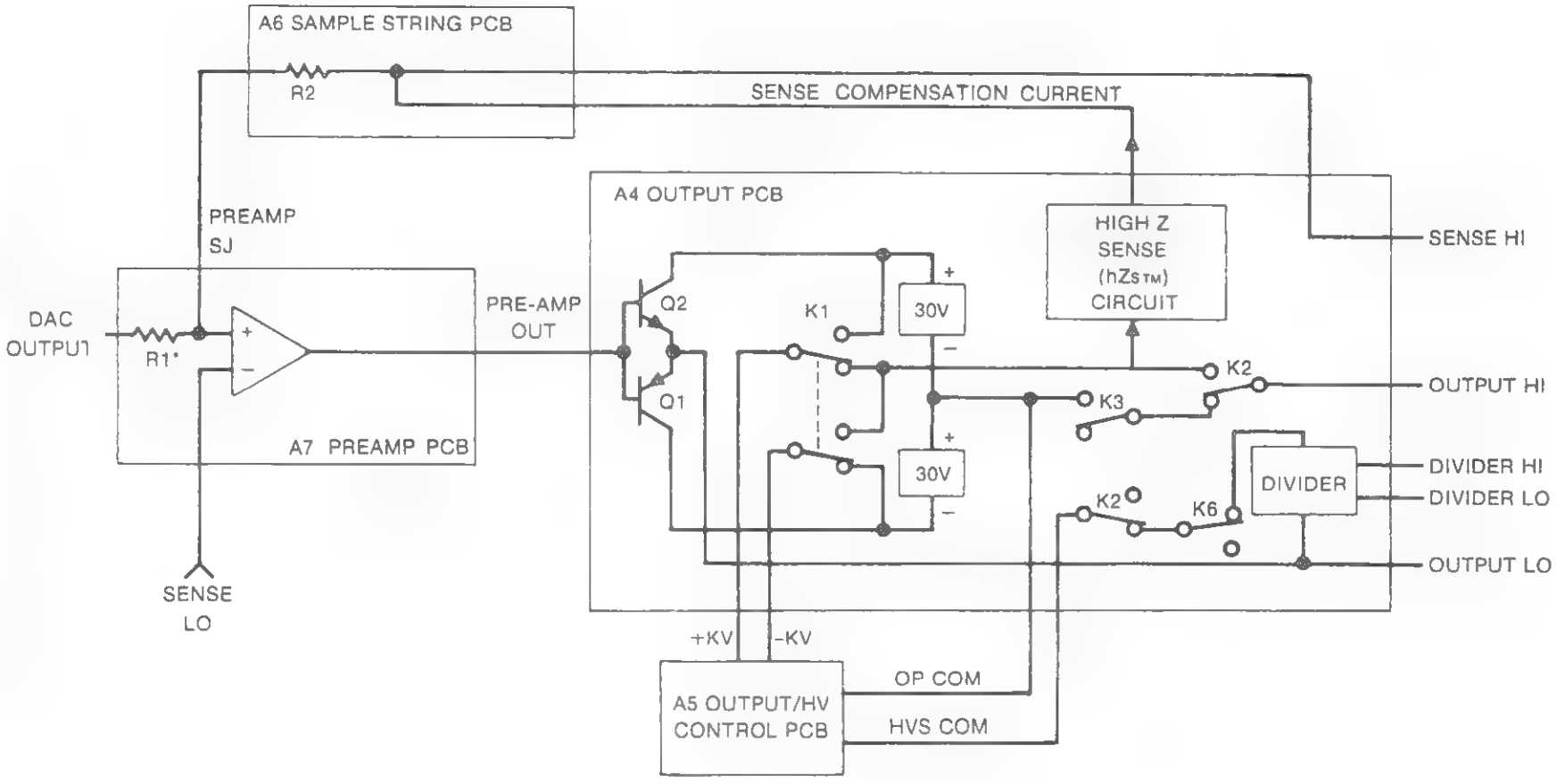
6-49. The A12 Filter A PCB receives various ac voltages from the A11 Guarded Xfmr Term PCB and provides rectified and filtered dc voltages to the A10 Inside Regulator PCB. Test points at the top of the A12 Filter A PCB provide the means for checking the various dc output voltages.

6-50. A10 INSIDE REGULATOR PCB

6-51. The A10 Inside Regulator PCB contains the auxiliary supply voltages used by circuits inside the guard. Comparator circuits on the pcb continuously monitor the various regulated supply voltages to detect any large deviation from nominal output voltage. A deviation of approximately 12 percent from nominal produces an output low signal from the monitor circuit.

Table 6-2. Output Gain

OUTPUT RANGE	OUTPUT GAIN	VALUE OF SAMPLE STRING R2 (kΩ)
0.22	2	40
2.2	2	40
11	1	20
22	2	40
175	25	500
1100	100	2000



*This resistor is physically located on the A6 Sample String PCB.

Figure 6-5. Output Amplifier Simplified Schematic

The output low signal turns on the LED indicator at the tip of the circuit board and produces a logic low on the GPSF line as a signal to the guarded microprocessor.

6-52. A13 FILTER B PCB

6-53. The A13 Filter B PCB contains the high voltage generator and the rectifier filter circuits for the 20 volt oven supply. The output high voltage generator is controlled by the triac switching and square wave driver lines from the A5 Output/HV Control PCB.

6-54. A19 OUTSIDE GUARD TERM PCB

6-55. The A19 Outside Guard Term PCB contains the rectifiers and filters that supply the A17 Outside Guard Regulator PCB. Each secondary winding is separately fused to guard against damage to the transformer in the event that a secondary short fails to blow the line fuse. Test points at the tip of the printed circuit boards allow voltage checks of the unregulated supplies.

6-56. A17 OUTSIDE GUARD REGULATOR PCB

6-57. The A17 Outside Guard Regulator PCB provides auxiliary power and error detection circuits for circuits outside the guard (including the front panel). Test points located at the top of the circuit board provide a means of checking individual supply voltages.

6-58. All supplies are continuously monitored by the error detection circuits. The outputs of the power supply monitors are ORed in the error detection circuit to provide an output (PSF) that is monitored by the guarded microprocessor. If one of the regulated output is low a PSF signal is sent to the guarded microprocessor for appropriate action and a LED indicator located near the top of the circuit board is turned on to signal a power supply fault condition.

6-59. The POP signal is a power-on-reset signal. POP is used to clear latches and start logic circuits from a known state following power supply turn-on or interruption.

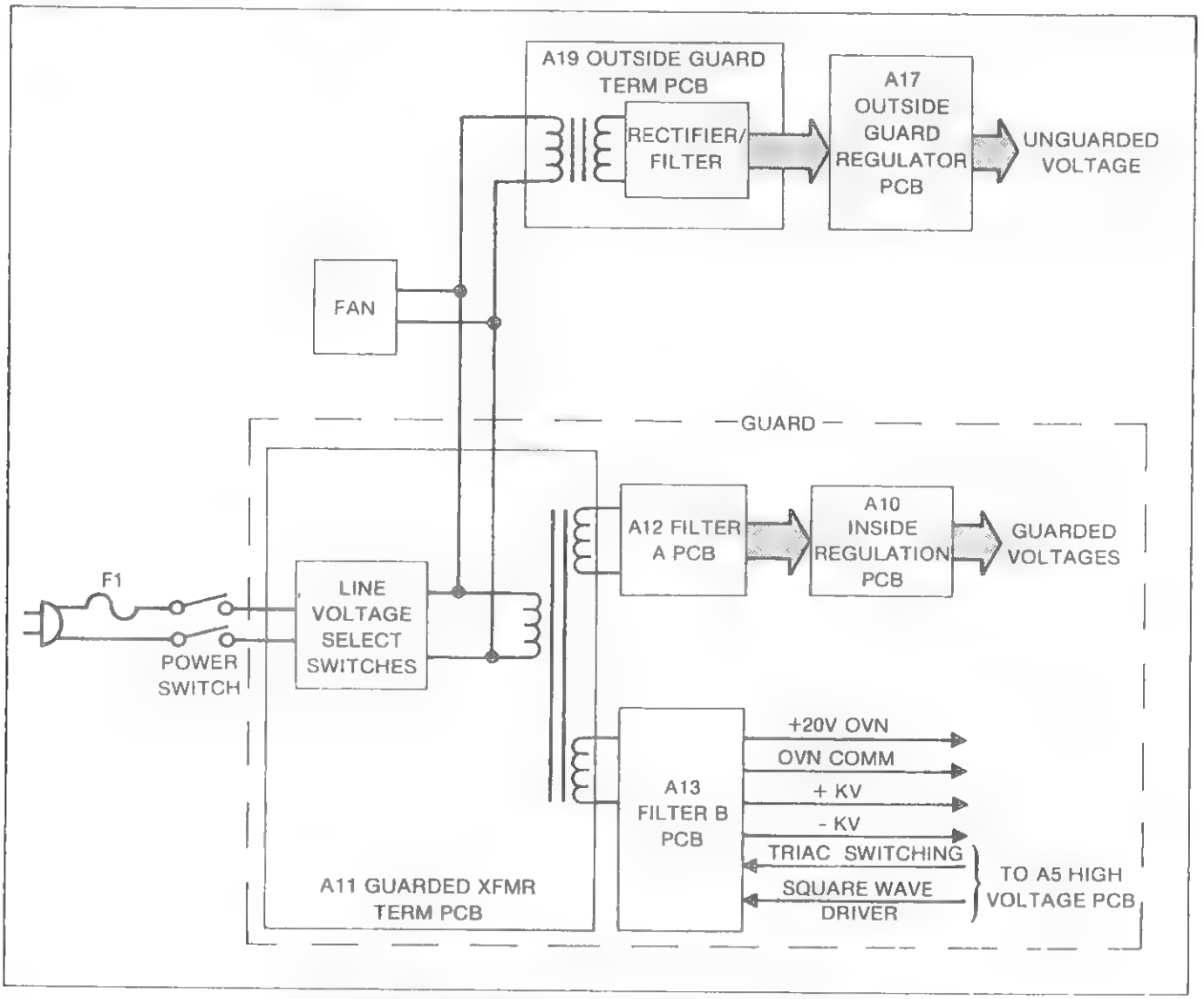


Figure 6-6. 5440A Power Supply Simplified Schematic

6-60. SOFTWARE FUNCTIONAL OVERVIEW

6-61. As Figure 6-7 shows, the 5440A software is conceptually organized into two major parts with the machine state between. The first part controls the internal instrument interfaces (interfaces between the software and the control circuits). The second part controls the local and remote external interfaces. The machine state is an internal representation of how the analog hardware is to be configured (output voltage, range, mode, etc.).

6-62. Figure 6-7 also shows the five 5440A software processes: local interface, remote interface, command processor, analog control, and printer and non-volatile memory control. Each of the functions runs independently, as if each were running on a separate microprocessor. Note that the functional separation of software is different than the physical separation. Physically, most of the local software resides in the front panel microprocessor, and the remaining software resides in the main microprocessor.

6-63. The two user interfaces, remote and local, translate the interface specific commands into the very simple commands expected by the command processor. The command processor executes all user commands.

6-64. As an example of how the user interface and command processor function, follow the activities which occur when a new output voltage is entered from the front panel. First, the local interface software interacts with the user at the keyboard level by prompting for input and displaying the keys pressed. When the output is entered by depressing the ENTER/YES (DATA ENTRY) key the local interface software sends a message to the command processor requesting that the output change. The command processor checks the new output against the programmed limits. If the new output is within limits, this new output is written in the machine state data area. The command processor tells the analog control and the local interface to change the output value. The local interface software updates the output displays. The

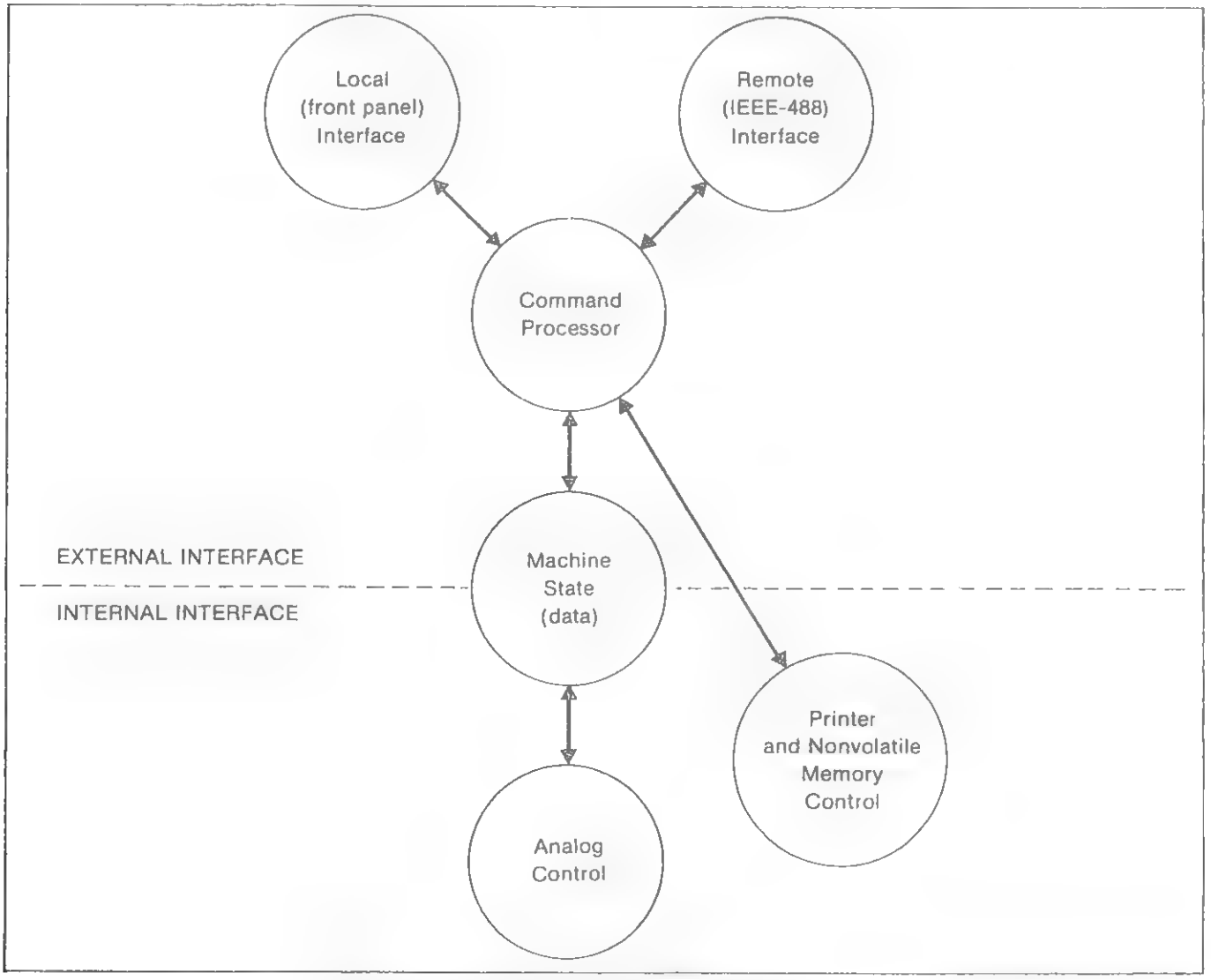


Figure 6-7. 5440A Software Process Diagram

analog control software makes the appropriate changes to the analog hardware.

6-65. Since the 5440A software processes are independently executing pieces of software, they have three unique properties.

1. Each of the processes can run at its own rate of speed. This means that the analog control process can take as much time as is necessary to set up the analog hardware without holding up the user interface.

2. The command processor has the ability to abort long operations. For example, the internal calibration is executed by the analog control process, and can take up to six minutes to complete. When an internal calibration is aborted by pressing the RESET key, the command processor signals the analog control to stop executing the internal calibration.

3. Multiple activities to be carried on simultaneously by the software. For example, the printer and non-volatile memory control process is used to print listings and to store or recall EAROM data. The analog control of the instrument can still proceed (including monitoring analog circuits for faults) while simultaneously printing or writing to non-volatile memory.

6-66. INTERNAL CALIBRATION

6-67. Since the internal calibration feature is essential to confidence in the 5440A performance, the theory of operation of the internal calibration process is described separate from the theory of normal 5440A operation. The internal calibration can be run daily without the need for external standards or operator intervention.

6-68. The purpose of the internal calibration is to measure and correct for small shifts in offset voltages and amplifier gains in the analog circuits thereby improving output accuracy. The measurements are taken by an internal analog-to-digital converter whose input can be switched to different points in the instrument. The process is controlled by the main microprocessor through a program in the ROM.

6-69. Requesting an internal calibration from the front panel of via the IEEE-488 interface starts the following sequence of measurements and adjustments controlled by the main microprocessor:

1. The analog-to-digital converter is calibrated against a dedicated +2.5V reference.

2. The 5440A is zeroed on each voltage range (±10V through ±1000V) to correct for amplifier offset voltage drift using the following process:

a. Internally, there is a dc amplifier with programmable gain. The input of this amplifier can be switched between a short and the 5440A output. The output of this amplifier is connected to a multiplexer located on the A5 Output/HV Control PCB. The output of the multiplexer is then channeled to the analog-to-digital converter.

b. The output of the amplifier is measured with the amplifier input shorted.

c. The output of the amplifier is measured with the amplifier input connected to the 5440A output.

d. The difference between the measurements is used to calculate the zero offset of the 5440A output. If the 5440A output zero offset is outside preset limits, then the offset is used to calculate a new DAC setting. The new DAC setting should zero the 5440A output. During the zeroing process, the program measures the ratio of resolution between the two DAC input channels.

e. If the 5440A output is within predetermined limits, the program continues. If the output is not within the limits, Step 2 is repeated until the output is within limits.

3. Next, the internal calibration program measures internal amplifier gain shifts. The A7 Preamp PCB is used in a dc amplifier configuration (Figure 6-8) with a gain of 600 to determine resistor gain errors in the A9 REF/DAC Analog PCB and the A6 Sample String PCB. The shifts in gain are determined by comparing the new measurements to the measurements made during the last internal calibration.

4. The last program operation is to calculate and store new calibration constants as follows:

a. The program first calculates new gain constants for each range by taking the old gain constants from memory and adjusting their value according to the amount of gain shift measured.

b. The program uses the new gain constant, the DAC setting that gave zero volts out, and the measured value of channel resolutions to calculate the offset in volts for each range, on both polarities.

c. The new calibration constants are stored in the non-volatile memory. The new calibration constants replace the old calibration constants

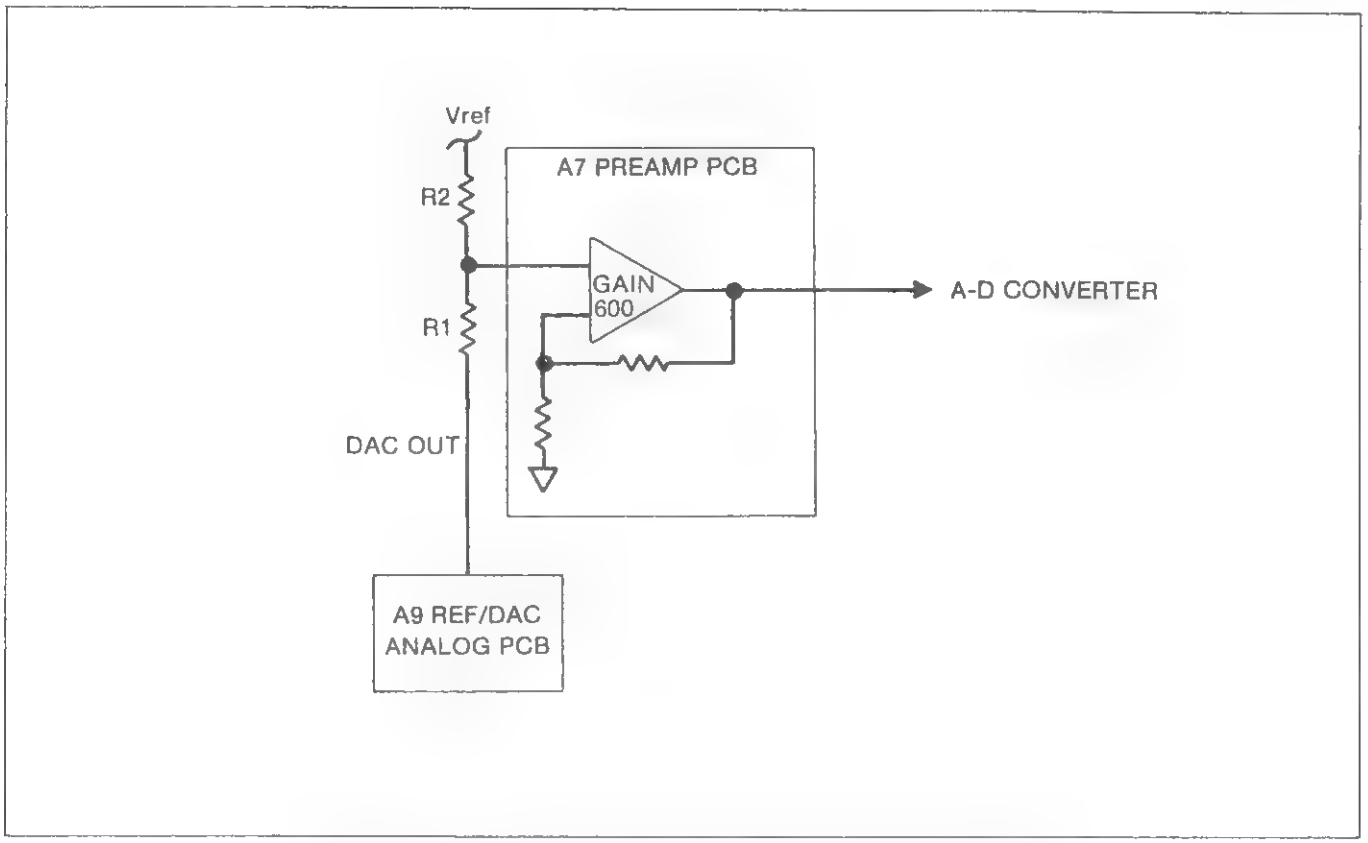


Figure 6-8. A7 Preamplifier Configuration During Internal Calibration

Section 7
Accessory Information

7-1. INTRODUCTION

7-2. The information in this section briefly describes each accessory available for use with the 5440A. The accessories are arranged in numerical order by model number.

7-3. ADDITIONAL PROCEDURE STORAGE MODULE (5440A-7001)

7-4. The 5440A-7001 Additional Procedure Storage Module provides non-volatile storage of up to 60 complete 5440A front panel setups in EAROM memory. With power removed from the 5440A or with the storage module removed from the 5440A, the front panel setups should be retained for several years. The module plugs into the 5540A front panel.

7-5. LOW THERMAL EMF PLUG-IN CABLES (5440A-7002)

7-6. The 5440A-7002 Low Thermal EMF Plug-in Cables are three special length, shielded cables. These cables are constructed to minimize thermal (Seebeck) emf in the connections between the 5440A ouput and the input of the device the 5440A is driving.

7-7. 1780A RS-232-C CABLE (Y1707)

7-8. The two meter Y1707 cable is intended to connect a 1780A InfoTouch Display to the 5440A. The Y1707 extends the RS-232-C interface on the 5440A without changing its function. The male connector on one end of the cable is attached, pin-for-pin, to the female connector on the other end of the cable.

7-9. 5205A INTERFACE CABLE (Y5001)

7-10. The Y5001 is a 0.7 meter cable used to connect the Fluke 5205A Precision Power Amplifier to the 5440A to establish a Y5000 Boost Interface. The cable has two connectors on each end. One connector on each end is used for control signals. The other connector is used for the boost voltage output of the 5440A.

7-11. 5220A INTERFACE CABLE (Y5002)

7-12. The Y5002 is a 0.7 meter cable used to connect the Fluke 5220A Transconductance Amplifier to the 5440A to establish a Y5000 Boost Interface. The cable has two connectors on each end. One connector on each end is used for control signals. The other connector is used for the boost voltage output of the 5440A.

7-13. ARMORED IEEE-488 INTERFACE CABLES (Y8021, Y8022, AND Y8023)

7-14. The 5440A can be connected to the IEEE-488 interface using any of the three armored IEEE-488 compatible interface cables. The Y8021 is one meter. The Y8022 is two meters. The Y8023 is four meters.

Section 7
General Information

7-1. This section of the manual contains generalized user information as well as supplemental information to the List of Replaceable Parts contained in Section 5.

List of Abbreviations and Symbols

A or amp	ampere
ac	alternating current
af	audio frequency
a/d	analog-to-digital
assy	assembly
AWG	american wire gauge
B	bel
bcd	binary coded decimal
°C	Celsius
cap	capacitor
ccw	counterclockwise
cer	ceramic
cermet	ceramic to metal(seal)
ckt	circuit
cm	centimeter
cmrr	common mode rejection ratio
comp	composition
cont	continue
crt	cathode-ray tube
cw	clockwise
d/a	digital-to-analog
dac	digital-to-analog converter
dB	decibel
dc	direct current
dmm	digital multimeter
dvm	digital voltmeter
elect	electrolytic
ext	external
F	farad
°F	Fahrenheit
FET	Field-effect transistor
ff	flip-flop
freq	frequency
FSN	federal stock number
g	gram
G	giga (10^9)
gd	guard
Ge	germanium
GHz	gigahertz
gmv	guaranteed minimum value
gnd	ground
H	henry
hd	heavy duty
hf	high frequency
Hz	hertz
IC	integrated circuit
if	intermediate frequency
in	inch(es)
intl	internal
I/O	input/output
k	kilo (10^3)
kHz	kilohertz
kΩ	kilohm(s)
kV	kilovolt(s)
lf	low frequency
LED	light-emitting diode
LSB	least significant bit
LSD	least significant digit
M	mega (10^6)
m	milli (10^{-3})
mA	milliampere(s)
max	maximum
mf	metal film
MHz	megahertz
min	minimum
mm	millimeter
ms	millisecond
MSB	most significant bit
MSD	most significant digit
MTBF	mean time between failures
MTTR	mean time to repair
mV	millivolt(s)
mv	multivibrator
MΩ	megohm(s)
n	nano (10^{-9})
na	not applicable
NC	normally closed
(-) or neg	negative
NO	normally open
ns	nanosecond
opnl ampl	operational amplifier
p	pico (10^{-12})
para	paragraph
pcb	printed circuit board
pF	picofarad
pn	part number
(+) or pos	positive
pot	potentiometer
p-p	peak-to-peak
ppm	parts per million
PROM	programmable read-only memory
psi	pound-force per square inch
RAM	random-access memory
rf	radio frequency
rms	root mean square
ROM	read-only memory
s or sec	second (time)
scope	oscilloscope
SH	shield
Si	silicon
serno	serial number
sr	shift register
Ta	tantalum
tb	terminal board
tc	temperature coefficient or temperature compensating
tcxo	temperature compensated crystal oscillator
tp	test point
u or μ	micro (10^{-6})
uhf	ultra high frequency
us or μs	microsecond(s) (10^{-6})
uut	unit under test
V	volt
v	voltage
var	variable
vco	voltage controlled oscillator
vhf	very high frequency
vlf	very low frequency
W	watt(s)
ww	wire wound
xfmr	transformer
xsir	transistor
xtal	crystal
xtlo	crystal oscillator
Ω	ohm(s)
μ	micro (10^{-6})

Federal Supply Codes for Manufacturers

00213
Nytronics Comp Group Inc
Subsidiary of Nytronics Inc
Formerly Sage Electronics
Rochester, New York

00327
Welwyn International, Inc
Westlake, Ohio

00656
Aerovox Corp
New Bedford, Massachusetts

00686
Film Capacitors, Inc
Passaic, New Jersey

00779
AMP Inc
Harrisburg, Pennsylvania

01121
Allen-Bradley Co
Milwaukee, Wisconsin

01281
TRW Electronic Comp
Semiconductor Operations
Lawndale, California

01295
Texas Instruments, Inc
Semiconductor Group
Dallas, Texas

01537
Motorola Communications &
Electronics Inc
Franklin Park, Illinois

01686
RCL Electronics Inc
Manchester, New Hampshire

01730
Replaced by 73586

01884
Use 56289
Sprague Electric Co
Dearborn Electronic Div
Lockwood, Florida

02114
Ferroxcube Corp
Saugerties, New York

02131
General Instrument Corp
Harris ASW Div
Westwood, Maine

02395
Rason Mfg Co
Brooklyn, New York

02533
Snelgrove, C R Co , Ltd
Don Mills, Ontario, Canada
M3B 1M2

02606
Fenwal Labs
Div of Travenal Labs
Morton Grove, Illinois

02660
Bunker Ramo Corp , Conn Div
Formerly Amphenol-Borg
Electric Corp
Broadview, Illinois

02799
Areo Capacitors, Inc
Chatsworth, California

03508
General Electric Co
Semiconductor Products
Syracuse, New York

03614
Replaced by 71400

03651
Replaced by 44655

03797
Eldema Div
Genisco Technology Corp
Compton, California

03877
Transistron Electronic Corp
Wakefield, Massachusetts

03888
KDI Pyrofilm Corp
Whippany, New Jersey

03911
Clairex Electronics Div
Clairex Corp
Mt Vernon, New York

03980
Muirhead Inc
Mountainside, New Jersey

04009
Arrow Hart Inc
Hartford, Connecticut

04062
Replaced by 72136

04202
Replaced by 81312

04217
Essex International Inc
Wire & Cable Div
Anaheim, California

04221
Aemco, Div of
Midtex Inc
Mankato, Minnesota

04222
AVX Ceramics Div
AVX Corp
Myrtle Beach, Florida

04423
Telonic Industries
Laguna Beach, California

04645
Replaced by 75376

04713
Motorola Inc Semiconductor
Products
Phoenix, Arizona

04946
Standard Wire & Cable
Los Angeles, California

05082
Replaced by 94988

05236
Jonathan Mfg Co
Fullerton, California

05245
Components Corp now
Corcom, Inc
Chicago, Illinois

05277
Westinghouse Electric Corp
Semiconductor Div
Youngwood, Pennsylvania

05278
Replaced by 43543

05279
Southwest Machine &
Plastic Co
Glendora California

05397
Union Carbide Corp
Materials Systems Div
New York, New York

05571
Use 56289
Sprague Electric Co
Pacific Div
Los Angeles, California

05574
Viking Industries
Chatsworth, California

05704
Replaced by 16258

05820
Wakefield Engineering Inc
Wakefield, Massachusetts

06001
General Electric Co
Electronic Capacitor &
Battery Products Dept
Columbia, South Carolina

06136
Replaced by 63743

06383
Panduit Corp
Tinley Park, Illinois

06473
Bunker Ramo Corp
Amphenol SAMS Div
Chatsworth, California

06555
Beede Electrical Instrument Co
Penacook, New Hampshire

06739
Electron Corp
Littleton, Colorado

06743
Clevite Corp
Cleveland, Ohio

06751
Components, Inc Semcor Div
Phoenix, Arizona

06860
Gould Automotive Div
City of Industry, California

06961
Vernitron Corp , Piezo
Electric Div
Formerly Clevite Corp , Piezo
Electric Div
Bedford, Ohio

06980
Eimac Div
Varian Associates
San Carlos, California

07047
The Ross Milton Co
South Hampton Pennsylvania

07115
Replaced by 14674

07138
Westinghouse Electric Corp ,
Electronic Tube Div
Horsehead, New York

07233
TRW Electronic Components
Cinch Graphic
City of Industry, California

07256
Silicon Transistor Corp
Div of BBF Group Inc
Chelmsford, Massachusetts

07261
Aumet Corp
Culver City, California

07263
Fairchild Semiconductor
Div of Fairchild Camera
& Instrument Corp
Mountain View, California

07344
Bircher Co , Inc
Rochester, New York

07597
Burndy Corp
Tape/Cable Div
Rochester, New York

07792
Lerma Engineering Corp
Northampton, Massachusetts

07910
Teledyne Semiconductor
Formerly Continental Device
Hawthorne, California

07933
Use 49956
Raytheon Co
Semiconductor Div HQ
Mountain View, California

08225
Industro Transistor Corp
Long Island City, New York

Federal Supply Codes for Manufacturers (cont)

08261
Spectra Strip Corp
Garden Grove, California

08530
Reliance Mica Corp
Brooklyn, New York

08806
General Electric Co
Miniature Lamp Products Dept
Cleveland, Ohio

08863
Nylomatic Corp
Norrisville, Pennsylvania

08988
Use 53085
Skottie Electronics Inc
Archbald, Pennsylvania

09214
G E Co Semi-Conductor
Products Dept
Power Semi-Conductor
Products OPN Sec
Auburn, New York

09353
C and K Components
Watertown, Massachusetts

09423
Scientific Components, Inc
Santa Barbara, California

09922
Burndy Corp
Norwalk, Connecticut

09969
Dale Electronics Inc
Yankton, S Dakota

10059
Barker Engineering Corp
Formerly Amerace, Amerace
ESNA Corp
Kenilworth, New Jersey

11236
CTS of Berne
Berne, Indiana

11237
CTS Keene Inc
Paso Robles, California

11358
CBS Electronic Div
Columbia Broadcasting System
Newburyport, Minnesota

11403
Best Products Co
Chicago, Illinois

11503
Keystone Columbia Inc
Warren, Michigan

11532
Teledyne Relays
Hawthorne, California

11711
General Instrument Corp
Rectifier Division
Hicksville, New York

11726
Qualidyne Corp
Santa Clara, California

12014
Chicago Rivet & Machine Co
Bellwood, Illinois

12040
National Semiconductor Corp
Danburry, Connecticut

12060
Diodes, Inc
Chatsworth, California

12136
Philadelphia Handle Co
Camden, New Jersey

12300
Potter-Brumfield Div
AMF Canada LTD
Guelph, Ontario, Canada

12323
Presin Co , Inc
Shelton, Connecticut

12327
Freeway Corp formerly
Freeway Washer & Stamping Co
Cleveland, Ohio

12443
The Budd Co Polychem Products
Plastic Products Div
Bridgeport, Pennsylvania

12615
U S Terminals Inc
Cincinnati, Ohio

12617
Hamlin Inc
Lake Mills, Wisconsin

12697
Clarostat Mfg Co
Dover, New Hampshire

12749
James Electronics
Chicago, Illinois

12856
Micrometals
Sierra Madre, California

12954
Dickson Electronics Corp
Scottsdale, Arizona

12969
Unitrode Corp
Watertown, Massachusetts

13103
Thermalloy Co , Inc
Dallas, Texas

13327
Solitron Devices Inc
Tappan, New York

13511
Amphenol Cadre Div
Bunker-Ramo Corp
Los Gatos, California

13606
Use 56289
Sprague Electric Co
Transistor Div
Concord, New Hampshire

13839
Replaced by 23732

14099
Semtech Corp
Newbury Park, California

14140
Edison Electronic Div
Mc Gray-Edison Co
Manchester, New Hampshire

14193
Cal-R-Inc formerly
California Resistor, Corp
Santa Monica, California

14298
American Components, Inc
an Insilco Co
Conshohocken, Pennsylvania

14655
Cornell-Dublier Electronics
Division of Federal Pacific
Electric Co Govt Control Dept
Newark, New Jersey

14752
Electro Cube Inc
San Gabriel, California

14869
Replaced by 96853

14936
General Instrument Corp
Semi Conductor Products Group
Hicksville, New York

15636
Elec-Trol Inc
Saugus, California

15801
Fenwal Electronics Inc
Div of Kidde Walter and Co , Inc
Framingham, Massachusetts

15818
Teledyne Semiconductors,
formerly Ametco Semiconductor
Mountain View, California

15849
Litton Systems Inc. Useco Div
formerly Useco Inc
Van Nuys, California

15898
International Business
Machines Corp
Essex Junction, Vermont

15909
Replaced by 14140

16258
Space-Lok Inc
Burbank, California

16299
Corning Glass
Electronic Components Div
Raleigh, North Carolina

16332
Replaced by 28478

16473
Cambridge Scientific Ind
Div of Chemed Corporation
Cambridge, Maryland

16742
Paramount Plastics
Fabricators, Inc
Downey, California

16758
Delco Electronics
Div of General Motors Corp
Kokomo, Indiana

17001
Replaced by 71468

17069
Circuit Structures Lab
Burbank, California

17338
High Pressure Eng Co , Inc
Oklahoma City, Oklahoma

17545
Atlantic Semiconductors, Inc
Asbury Park, New Jersey

17856
Siliconix, Inc
Santa Clara, California

17870
Replaced by 14140

18178
Vactec Inc
Maryland Heights, Missouri

18324
Signetics Corp
Sunnyvale, California

18612
Vishay Resistor Products Div
Vishay Intertechnology Inc
Malvern, Pennsylvania

18736
Voltronics Corp
Hanover, New Jersey

18927
GTE Sylvania Inc
Precision Material Group
Parts Division
Titusville, Pennsylvania

19451
Perine Machinery & Supply Co
Seattle, Washington

19701
Electro-Midland Corp
Mepco-Electra Inc
Mineral Wells, Texas

20584
Enochs Mfg Inc
Indianapolis, Indiana

Federal Supply Codes for Manufacturers (cont)

20891
Self-Organizing Systems, Inc
Dallas, Texas

21604
Bucheye Stamping Co
Columbus, Ohio

21845
Solitron Devices Inc
Transistor Division
Riveria Beach, Florida

22767
ITT Semiconductors
Palo Alto, California

23050
Product Comp Corp
Mount Vernon, New York

23732
Tracor Inc
Rockville, Maryland

23880
Stanford Applied Engrng
Santa Clara, California

23936
Pamotor Div , Wm J Purdy Co
Burlingame, California

24248
Replaced by 94222

24355
Analog Devices Inc
Norwood, Massachusetts

24655
General Radio
Concord, Massachusetts

24759
Lenox-Fugle Electronics Inc
South Plainfield, New Jersey

25088
Siemen Corp
Isilen, New Jersey

25403
Amperex Electronic Corp
Semiconductor &
Micro-Circuits Div
Slatersville, Rhode Island

27014
National Semiconductor Corp
Santa Clara, California

27264
Molex Products
Downers Grove, Illinois

28213
Minnesota Mining & Mfg Co
Consumer Products Div
St Paul, Minnesota

28425
Serv-/-Link formerly
Bohannan Industries
Fort Worth, Texas

28478
Deltrol Controls Div
Deltrol Corporation
Milwaukee, Wisconsin

28480
Hewlett Packard Co
Corporate HQ
Palo Alto, California

28520
Heyman Mfg Co
Kenilworth, New Jersey

29083
Monsanto, Co , Inc
Santa Clara, California

29604
Stackpole Components Co
Raleigh, North Carolina

30148
AB Enterprise Inc
Ahoskie, North Carolina

30323
Illinois Tool Works, Inc
Chicago, Illinois

31091
Optimax Inc
Colmar, Pennsylvania

32539
Mura Corp
Great Neck, New York

32767
Griffith Plastic Corp
Burlingame, California

32879
Advanced Mechanical
Components
Northridge, California

32897
Erie Technological Products, Inc
Frequency Control Div
Carlisle, Pennsylvania

32997
Bourns Inc
Trimpot Products Division
Riverside, California

33173
General Electric Co
Products Dept
Owensboro, Kentucky

34333
Silicon General
Westminister, California

34335
Advanced Micro Devices
Sunnyvale, California

34802
Electromotive Inc
Kenilworth, New Jersey

37942
P R Mallory & Co , Inc
Indianapolis, Indiana

42498
National Radio
Melrose, Massachusetts

43543
Nytronics Inc
Transformer Co Div
Geneva, New York

44655
Ohmite Mfg Co
Skokie, Illinois

49671
RCA Corp
New York, New York

49956
Raytheon Company
Lexington, Massachusetts

50088
Mostek Corp
Carrollton, Texas

50579
Litronix Inc
Cupertino, California

51605
Scientific Components Inc
Linden, New Jersey

53021
Sangamo Electric Co
Springfield, Illinois

54294
Cutler-Hammer Inc formerly
Shallcross, A Cutler-Hammer Co
Selma, North Carolina

55026
Simpson Electric Co
Div of Am Gage and Mach Co
Elgin, Illinois

56289
Sprague Electric Co
North Adams, Massachusetts

58474
Superior Electric Co
Bristol, Connecticut

60399
Torin Corp formerly
Torrington Mfg Co
Torrington, Connecticut

63743
Ward Leonard Electric Co , Inc
Mount Vernon, New York

64834
West Mfg Co
San Francisco, California

65092
Weston Instruments Inc
Newark, New Jersey

66150
Winslow Tele-Tronics Inc
Eaton Town, New Jersey

70485
Atlantic India Rubber Works
Chicago, Illinois

70563
Amperite Company
Union City, New Jersey

70903
Belden Corp
Geneva, Illinois

71002
Birnback Radio Co , Inc
Freeport, New York

71400
Bussmann Mfg
Div of McGraw-Edison Co
Saint Louis, Missouri

71450
CTS Corp
Elkhart, Indiana

71468
ITT Cannon Electric Inc
Santa Ana, California

71482
Clare, C P & Co
Chicago, Illinois

71590
Centrelab Electronics
Div of Globe Union Inc
Milwaukee, Wisconsin

71707
Coto Coil Co , Inc
Providence, Rhode Island

71744
Chicago Miniature Lamp Works
Chicago, Illinois

71785
TRW Electronics Components
Cinch Connector Operations Div
Elk Grove Village
Chicago, Illinois

72005
Wilber B Driver Co
Newark, New Jersey

72092
Replaced by 06980

72136
Electro Motive Mfg Co
Williamantic, Connecticut

72259
Nytronics Inc
Pelham Manor, New Jersey

72619
Dialight Div
Amperex Electronic Corp
Brooklyn, New York

72653
G C Electronics
Div of Hydrometals, Inc
Brooklyn, New York

72665
Replaced by 90303

72794
Dzus Fastener Co , Inc
West Islip, New York

72928
Gulton Ind Inc
Gudeman Div
Chicago, Illinois

72982
Erie Tech Products Inc
Erie, Pennsylvania

73138
Bechman Instrument Inc
Helipot Division
Fullerton, California

73293
Hughes Aircraft Co
Electron Dynamics Div
Torrance, California

73445
Amperex Electronic Corp
Hicksville, New York

73559
Carling Electric Inc
West Hartford, Connecticut

73586
Circle F Industries
Trenton, New Jersey

73734
Federal Screw Products, Inc
Chicago, Illinois

73743
Fischer Special Mfg Co
Cincinnati, Ohio

73899
JFD Electronics Co
Components Corp
Brooklyn, New York

73949
Guardian Electric Mfg Co
Chicago, Illinois

74199
Quan Nichols Co
Chicago, Illinois

74217
Radio Switch Corp
Marlboro, New Jersey

74276
Signalite Div
General Instrument Corp
Neptune, New Jersey

74306
Piezo Crystal Co
Carlisle, Pennsylvania

74542
Hoyt Elect Instr Works
Penacook, New Hampshire

74970
Johnson E F , Co
Waseca, Minnesota

75042
TRW Electronics Components
IRC Fixed Resistors
Philadelphia, Pennsylvania

75376
Kurz-Kasch Inc
Dayton, Ohio

75378
CTS Knights Inc
Sandwich, Illinois

75382
Kulka Electric Corp
Mount Vernon, New York

75915
Littlefuse Inc
Des Plaines, Illinois

76854
Oak Industries Inc
Switch Div
Crystal Lake, Illinois

77342
AMF Inc
Potter & Brumfield Div
Princeton, Indiana

77638
General Instrument Corp
Rectifier Division
Brooklyn, New York

77969
Rubbercraft Corp of CA LTD
Torrance, California

78189
Shakeproof
Div of Illinois Tool Works Inc
Elgin, Illinois

78277
Sigma Instruments, Inc
South Braintree, Massachusetts

78488
Stackpole Carbon Co
Saint Marys, Pennsylvania

78553
Eaton Corp Engineered
Fastener Div
Tinnerman Plant
Cleveland, Ohio

79136
Waldes Kohinoor Inc
Long Island City, New York

79497
Western Rubber Company
Goshen, Indiana

79963
Zierick Mfg Corp
Mt Kisko, New York

80031
Electro-Midland Corp
Mepco Div
A North American Phillips Co
Norristown, New Jersey

80145
LFE Corp , Process Control Div
formerly API Instrument Co
Chesterland, Ohio

80183
Use 56289
Sprague Products
North Adams, Massachusetts

80294
Bourns Inc , Instrument Div
Riverside, California

80583
Hammarlund Mfg Co , Inc
Red Bank, New Jersey

80640
Arnold Stevens, Inc
South Boston, Massachusetts

81073
Grayhill, Inc
La Grange, Illinois

81312
Winchester Electronics
Div of Litton Industries Inc
Oakville, Connecticut

81483
Therm-O-Disc Inc
Mansfield, Ohio

81483
International Rectifier Corp
Los Angeles, California

81590
Korry Mfg Co
Seattle, Washington

81741
Chicago Lock Co
Chicago, Illinois

82305
Palmer Electronics Corp
South Gate, California

82389
Switchcraft Inc
Chicago, Illinois

82415
North American Phillips
Controls Corp
Frederick, Maryland

82872
Roanwell Corp
New York, New York

82877
Rotron Inc
Woodstock, New York

82879
ITT Royal Electric Div
Pawtucket, Rhode Island

83003
Varo Inc
Garland, Texas

83058
The Carr Co , United Can Div
of TRW
Cambridge, Massachusetts

83298
Bendix Corp
Electric Power Div
Eatontown, New Jersey

83330
Herman H Smith, Inc.
Brooklyn, New York

83478
Rubbercraft Corp
of America, Inc
West Haven, Connecticut

83594
Burroughs Corp
Electronic Components Div
Plainfield, New Jersey

83740
Union Carbide Corp
Battery Products Div
formerly Consumer Products Div
New York, New York

84171
Arco Electronics
Great Neck, New York

84411
TRW Electronic Components
TRW Capacitors
Ogallala, Nebraska

84613
Fuse Indicator Corp
Rockville, Maryland

84682
Essex International Inc
Industrial Wire Div.
Peabody, Massachusetts

86577
Precision Metal Products
of Malden Inc
Stoneham, Massachusetts

86684
Radio Corp of America
Electronic Components Div
Harrison, New Jersey

86928
Seastrom Mfg Co , Inc
Glendale, California

87034
Illuminated Products Inc
Subsidiary of Oak Industries Inc
Anahiem, California

88219
Gould Inc
Industrial Div
Trenton, New Jersey

88245
Litton Systems Inc
Useco Div
Van Nuys, California

88419
Cornell-Dubilier Electronic Div
Federal Pacific Co
Fuquay-Varian, North Carolina

88486
Plastic Wire & Cable
Jewitt City, Connecticut

88690
Replaced by 04217

89536
John Fluke Mfg Co , Inc
Seattle, Washington

89730
G E Co , Newark Lamp Works
Newark, New Jersey

Federal Supply Codes for Manufacturers (cont)

90201
Mallory Capacitor Co
Div of P R Mallory Co , Inc
Indianapolis, Indiana

90211
Use 56365
Square D Co
Chicago, Illinois

90215
Best Stamp & Mfg Co
Kansas City, Missouri

90303
Mallory Battery Co
Div of Mallory Co , Inc
Tarrytown, New York

91094
Essex International Inc
Suglex/IWP Div
Newmarket, New Hampshire

91293
Johanson Mfg Co
Boonton, New Jersey

91407
Replaced by 58474

91502
Associated Machine
Santa Clara, California

91506
Augat Inc
Attleboro, Massachusetts

91637
Dale Electronics Inc
Columbus, Nebraska

91662
Elco Corp
Willow Grove, Pennsylvania

91737
Use 71468
Gremar Mfg Co , Inc
ITT Cannon/Gremar
Santa Ana, California

91802
Industrial Devices, Inc
Edgewater, New Jersey

91833
Keystone Electronics Corp
New York, New York

91836
King's Electronics Co , Inc
Tuckahoe, New York

91929
Honeywell Inc
Micro Switch Div
Freeport, Illinois

91934
Miller Electric Co , Inc
Div of Aunet
Woonsocket, Rhode Island

92194
Alpha Wire Corp
Elizabeth, New Jersey

93332
Sylvania Electric Products
Semiconductor Products Div
Woburn, Massachusetts

94145
Replaced by 49956

94154
Use 94988
Wagner Electric Corp
Tung-Sol Div
Newark, New Jersey

94222
Southco Inc formerly
South Chester Corp
Lester, Pennsylvania

95146
Alco Electronic Products Inc
Lawrence, Massachusetts

95263
Leecraft Mfg. Co
Long Island City, New York

95264
Replaced by 98278

95275
Vitramon Inc
Bridgeport, Connecticut

95303
RCA Corp
Receiving Tube Div
Cincinnati, Ohio

95348
Gordo's Corp
Bloomfield, New Jersey

95354
Methode Mfg Corp
Rolling Meadows, Illinois

95712
Bendix Corp
Electrical Components Div
Microwave Devices Plant
Franklin, Indiana

95987
Weckesser Co Inc
Chicago, Illinois

96733
San Fernando Electric Mfg Co
San Fernando, California

96853
Gulton Industries Inc
Measurement and Controls Div
formerly Rustrak Instruments Co
Manchester, New Hampshire

96881
Thomson Industries, Inc
Manhasset, New York

97540
Master Mobile Mounts, Div of
Whitehall Electronics Corp
Ft Meyers, Florida

97913
Industrial Electronic
Hardware Corp
New York, New York

97945
Penwalt Corp
SS White Industrial Products Div
Piscataway, New Jersey

97966
Replaced by 11358

98094
Replaced by 49956

98159
Rubber-Teck, Inc
Gardena, California

98278
Malco A Microdot Co , Inc
Connector & Cable Div
Pasadena, California

98291
Sealectro Corp
Mamaroneck, New York

98388
Royal Industries
Products Div
San Diego, California

98743
Replaced by 12749

98925
Replaced by 14433

99120
Plastic Capacitors, Inc
Chicago, Illinois

99217
Bell Industries Elect
Comp Div
formerly Southern Elect Div
Burbank, California

99392
STM
Oakland, California

99515
ITT Jennings Monrovia Plant
Div of ITT Jennings formerly
Marshall Industries Capacitor Div
Monrovia, California

99779
Use 29587
Bunker-Ramo Corp
Barnes Div
Landsdowne, Pennsylvania

99800
American Precision Industries Inc
Delevan Division
East Aurora, New York

99942
Centrelab Semiconductor
Centrelab Electronics Div of
Globe-Union Inc
El Monte, California

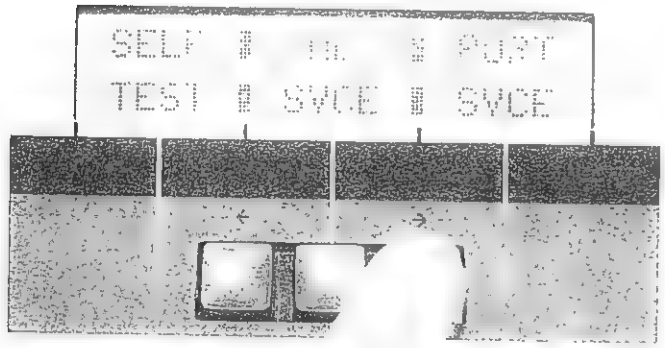
Toyo Electronics
(R-Ohm Corp)
Irvine, California

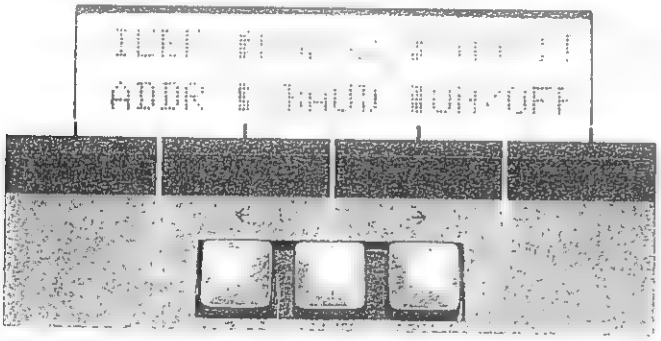
National Connector
Minneapolis, Minnesota

Input/Output Port Service

75. **Q. What does the PORT SVCE soft key under SVCE do?**

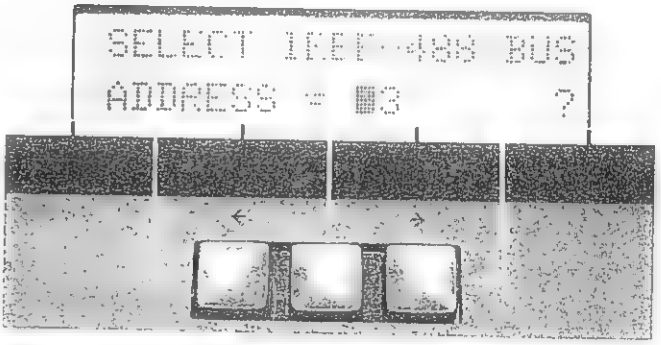
    A. The PORT SVCE soft key assigns values to input/output port settings like the IEEE-488 standard interface address and RS-232-C baud rate. It also turns the monitor function off or on during internal calibration and self-test.





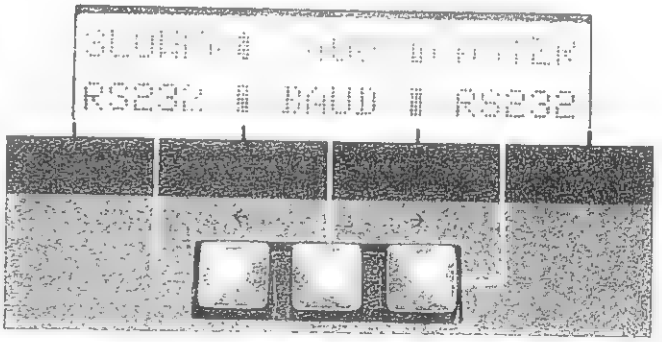
76. **Q. How do I view/change the IEEE-488 remote address?**

    A. Select SVCE, PORT SVCE, and IEEE ADDR. The current IEEE-488 remote address appears and the user enters the new address by pressing digit(s) followed by ENTER. The new IEEE-488 address is stored in non-volatile memory.

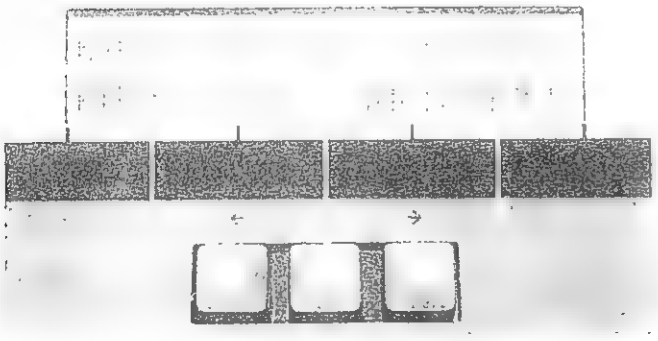


77. **Q. How do I view/change the RS-232-C printer baud rate?**

    A. Select SVCE, PORT SVCE, and RS232 BAUD. The current baud rate appears over the center soft key. Press the left or right soft key to decrease or increase the baud rate. Press the center soft key to select the new displayed baud rate. The new baud rate is stored in non-volatile memory.

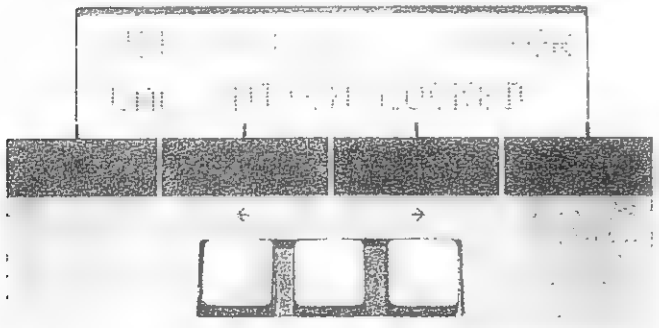


sequence for each of the ranges you want to calibrate. Upon completion, the instrument stores the calibration constants in nonvolatile memory.



71. **Q. Once external calibration has been performed is there any means to prevent altering the constant until the next necessary calibration period?**

    A. Yes, a switch on the rear of the 5440A disables the external calibration function. A dated calibration sticker placed over the switch ensures calibration integrity.



72. **Q. How do I know if external calibration is disabled?**

    A. If "EXT CAL" is initiated, the 5440A responds with the message "USER ENTRY ERROR CAL SWITCH LOCKED."

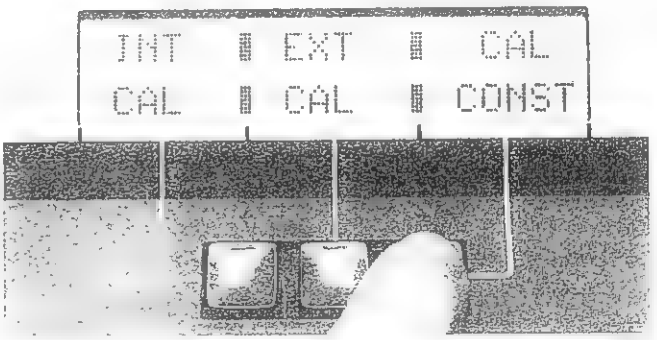
Calibration Constants

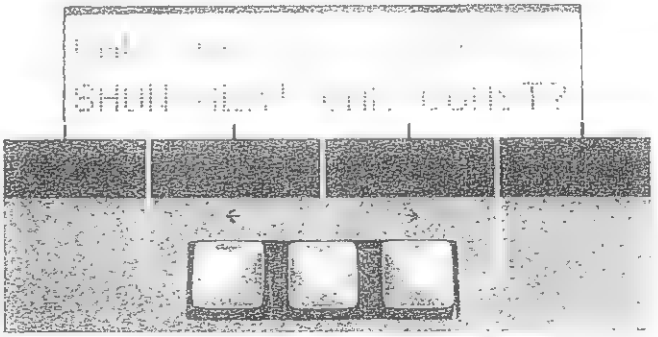
73. **Q. What are the calibration constants?**

    A. Calibration constants are data which helps the 5440A maintain its high accuracy. Data include gain and offset constants, gain shift from last external calibration, a-d resolution ratio, and a-d gain.

74. **Q. How do I list the calibration constants?**

    A. Select SVCE and press CAL SVCE and CAL CONST. The user views the constants one at a time; ENTER(YES) advances the alpha-numeric display to the next constant.





66. **Q. What do the values N1, N2 and offset mean (see Table 2)?**

A. N1 and N2 are the settings of the first channel and second channel of the two channel digital-to-analog converter (d-a). The offset is the voltage offset measured at the output terminals. When a range is zeroed, N1 and N2 are adjusted by the software until the offset is small enough to be within specification for that range.

67. **Q. Should I run internal calibration before external calibration?**

A. Yes, internal calibration zeroes the instrument. Since external calibration corrects primarily for changes in the gain constant, the offset must be known as closely as possible at the time of external calibration. It is then subtracted out of the output equation.

External Calibration

68. **Q. What instruments do I need to perform an external calibration of the 5440A?**

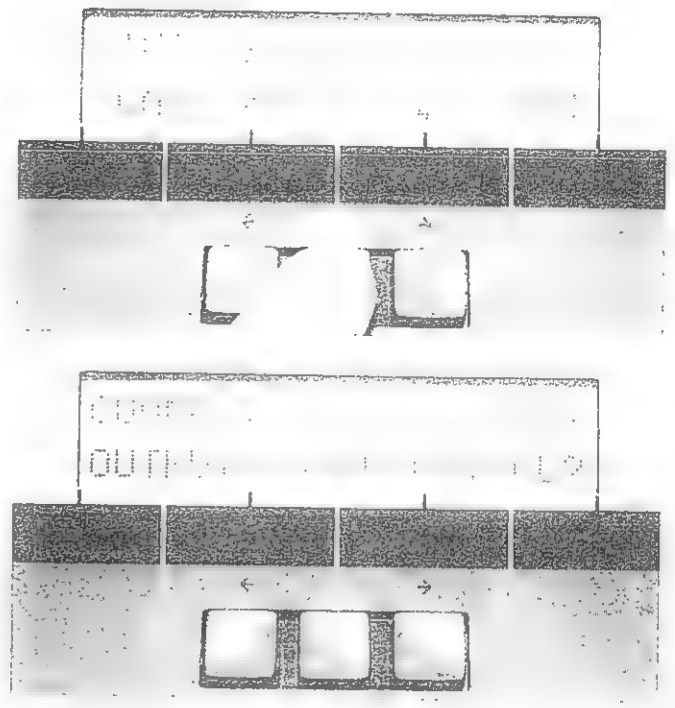
A. You will need an external standard voltage reference plus a null detector. The recommended equipment is the Fluke 732A DC Reference Standard and the Fluke 752A Reference Divider along with the Fluke 845A Null Detector.

69. **Q. Can I use standard cells for external calibration of the 5440A?**

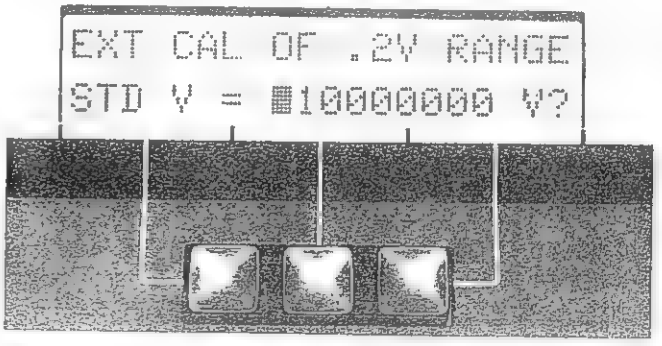
A. The 5440A allows the operator to enter the standard voltage reference value for each range. Therefore, the operator could use 10 standard cells with a precision divider to calibrate the 1100, 275, 20 and 10 volt ranges and a single standard cell to calibrate the 2.2V divided range. Standard cells cannot drive a divider for the 0.2V divided range.

70. **Q. How do I perform external calibration?**

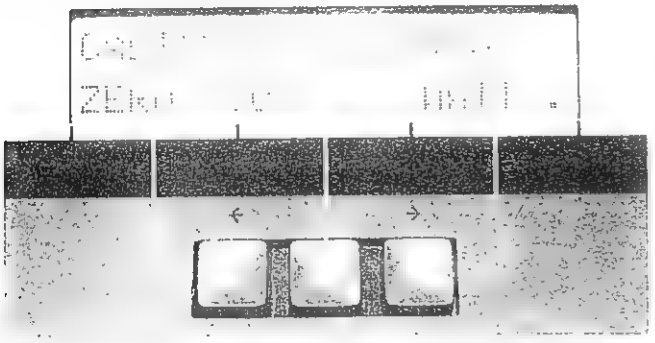
A. Calibrate your precision divider and zero your null detector if necessary. Select SVCE, CAL SVCE, and EXT CAL. The 5440A displays "CONNECT 5440 DIVIDER OUTPUT TO DO EXTCAL?". Connect your source lead to the divider terminals and press ENTER(YES). At any time you can press RESET to abort external calibration.

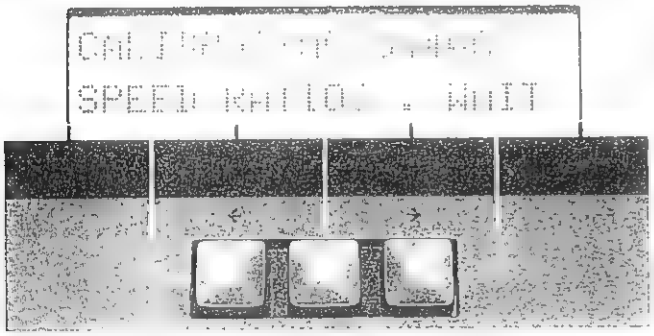


The instrument prompts "EXT CAL OF xxV range STD V = x.xxxxxxx V?" CLEAR(NO) skips external calibration of the displayed range, ENTER(YES) selects the default standard voltages (using the 732A/752A). The user may also enter digits followed by ENTER to select a different standard voltage. If you press ENTER(YES), the calibration value appears at the output display and OPR outputs the voltage.



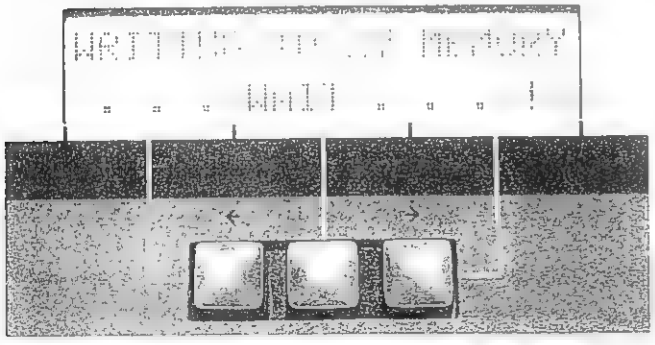
Null the reading by pressing the up/down edit buttons. The 5440A displays "EDIT OUTPUT VOLTAGE, PUSH ENTER WHEN NULL". After the user presses ENTER(YES), the 5440A continues to the next range automatically. Repeat the above





61. **Q. How does the 5440A remember the results of internal calibration?**

    A. At the end of internal calibration, the new calibration constants are written to nonvolatile memory.



62. **Q. Can I stop internal calibration once it has started?**

    A. The RESET key aborts internal calibration at any time.

63. **Q. How often should I initiate internal calibration?**

    A. Internal calibration removes both zero and gain shifts. It also improves the linearity of the instrument. For best results perform internal calibration on a daily basis or if room temperature makes a long-term change larger than 5°C.

64. **Q. How can I list internal calibration data?**

    A. Select SVCE and press PORT SVCE, MONIT ON/OFF, and MONIT ON. The 5440A automatically sends the data to a printer or monitor via the RS-232-C interface.

65. **Q. What data is accessible during internal calibration?**

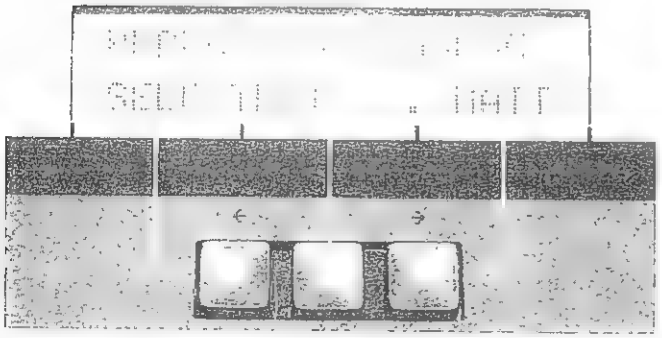
    A. Table 2 illustrates the 5440A Internal Calibration Data. It includes offset and gain information for each range, gain shift from the last internal calibration, and gain ratio for the two d-a converter channels (to improve linearity).

```
5440A INTERNAL CALIBRATION

JOHN FLUKE MFG. CO., INC.

+10V ZERO
     1: N1=  7, N2=14250, Offset    -1.2uV
     2: N1=  7, N2=14266, Offset     -.3uV

RESOLUTION RATIO
     1: N1=  6, N2=21558, Offset     -.1uV

-10V ZERO
     1: N1=  9, N2= 9500, Offset    -1.0uV
     2: N1=  9, N2= 9487, Offset     -.2uV

+20V ZERO
     1: N1=  7, N2=14529, Offset    -1.5uV

-20V ZERO
     1: N1=  9, N2= 9220, Offset    -1.0uV

+250V ZERO
     1: N1=  7, N2=14729, Offset    -9.1uV

-250V ZERO
     1: N1=  9, N2= 9023, Offset   -12.1uV

+1000V ZERO
     1: N1=  7, N2=14797, Offset   -71.8uV

-1000V ZERO
     1: N1=  9, N2= 8959, Offset   -76.7uV

GAIN SHIFT
     +10:  +376.24uV
     +20:  +442.87uV
     +HI:  +451.03uV
     -HI:  -838.11uV
     -20:  -830.32uV
     -10:  -764.04uV

END OF INTERNAL CALIBRATION
```

Table 2. Printed listing of 5440A Internal Calibration Data

58. **Q. Why is the output display active during analog and high voltage tests?**

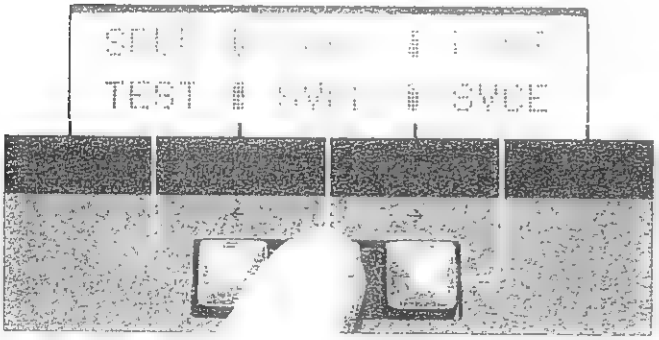
A. The display shows the maximum voltage level that could be present on the output terminals. In analog tests the maximum is 22V and in high voltage tests it is 1100V.



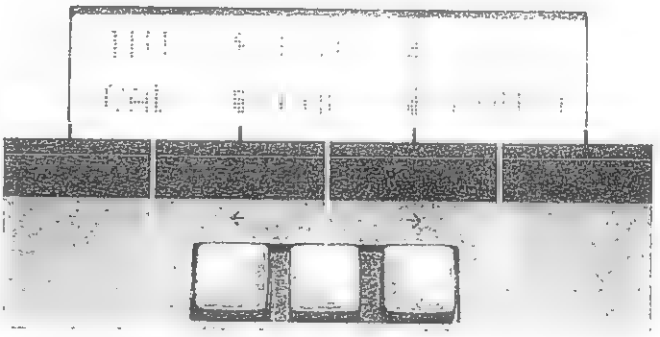
Calibration Service

59. **Q. What does the CAL SVCE soft key under SVCE do?**

A. The CAL SVCE soft button accesses calibration functions of the 5440A:



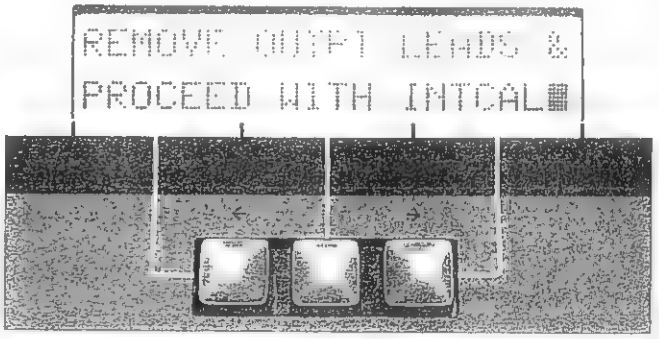
1) INT CAL starts a 5-minute stand alone internal calibration of the 5440A.
2) EXT CAL prompts the operator for calibration of the 5440A against an external standard voltage reference.
3) CAL CONST allows the operator to view the 5440A internal calibration constants one at a time.

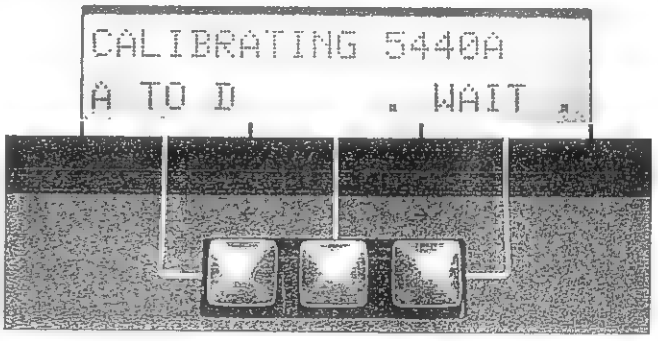


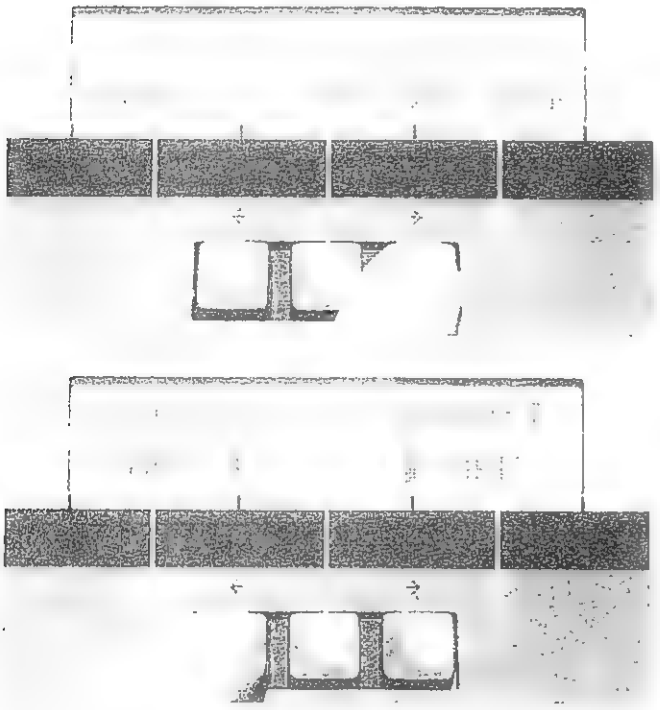
Internal Calibration

60. **Q. How is internal calibration of the 5440A performed?**

A. Select SVCE, then press the CAL SVCE soft key followed by the INT CAL soft key. The instrument displays "REMOVE OUTPUT LEADS & PROCEED WITH INTCAL?". Remove all leads attached to the terminals and press ENTER(YES). The 5440A performs a 5-minute self-calibration sequence. The instrument adjusts zeroes and offsets, ratios of gain setting resistors and displays the activity on the front panel. Calibration data may also be listed on a printer (see Table 2).







55. **Q. How does the test-point data help me diagnose my instrument?**

    A. Table 1 illustrates a listing of 5440A Analog Diagnostics data. This information, combined with the 5440A Service Manual, indicates possible fault errors in the instrument.

56. **Q. Does the 5440A provide any other troubleshooting aids?**

    A. Yes, the circuit boards themselves contain fault LEDs which can guide the user to a faulty board or function. Troubleshooting switches in the microprocessor boards allow generation of digital stimulus for functional troubleshooting.

57. **Q. Why are high voltage tests performed separately?**

    A. High voltage tests are separated from other analog tests because they use high voltages (up to 1100V) on the output terminals. By separating these tests the user can perform analog testing without having high voltage present.

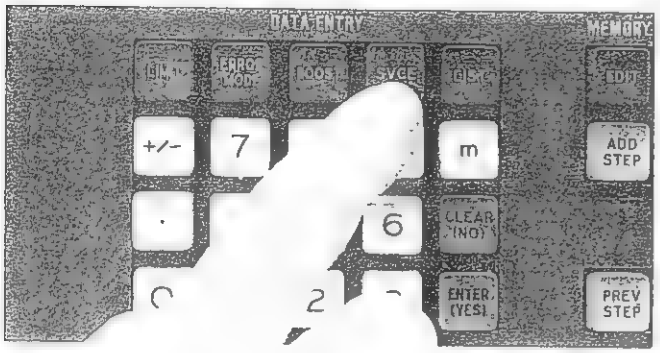
```
5440A ANALOG DIAGNOSTICS

JOHN FLUKE MFG. CO., INC.

     ADM1: +.000000V
     ADM2: -.002264V
     ADM3: +2.50904V
     M1: +13.0956V
     M1: +13.0956V
     M3: -11.7032V
     M4: -16.6795V
     C1: +4.97630V
     M5: -5.07129V
     M6: -16.3756V
     M7: -9.68921V
     C2: -13.0324V
     M8: -13.0353V
     C3: +.002917V
     M9: -4.80722V
     M10: -1.53899V
     C4: -3.17311V
     M11: -3.17305V
     C3:  .000056V
     M12: -16.0257V
     M13: -17.2470V
     C5: +1.22133V
     M14: -9.98358V
     M15: +9.90975V
     M16: -.036913V
     M17: -.000281V
     M18: -.001688V
     C6: +.001407V
     M19: -.000281V
     M20: -.001810V
     C7: +.001529V
     M21: +.000370V
     M22: +.000436V
     M23: -.000070V
     M24: -.000075V
     M25: +.004902V
     M26: +9.97560V
     M27: +19.9601V
     M28: -9.97560V
     M29: +.000000V
     M30: +19.8841V
     M31: -.120445V
     M32: +19.8841V
     M33: +.000445V
     M34: +19.9601V
     M35: +19.8615V
     M36: +22.2283V
     M37: -.312370V
     M38: +.050936V
     M39: +.822152V
     M40: +.828765V
     C8: -.006613V

END OF ANALOG DIAGNOSTICS
```

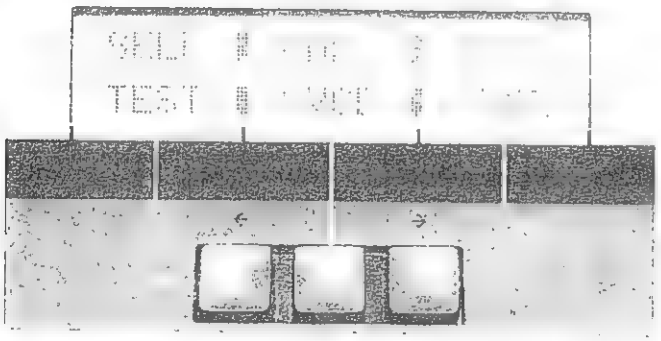
Table 1. Printed listing of 5440A Analog Diagnostics Data

Service (SVCE)

51. **Q. What does the SVCE button do?**

    A. The SVCE key accesses the service functions: SELF-TEST, CALibration SerViCE, and input/output PORT SerViCE.

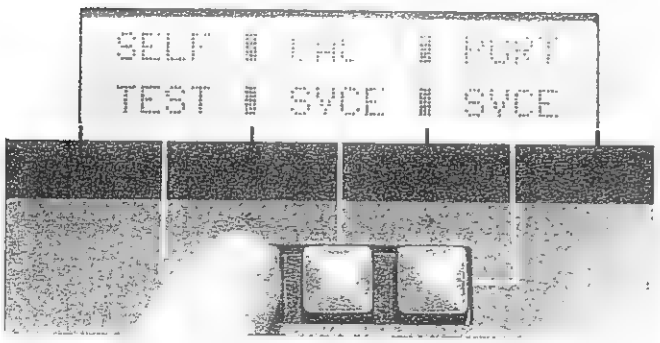




Self-Test

52. **Q. What is self-test?**

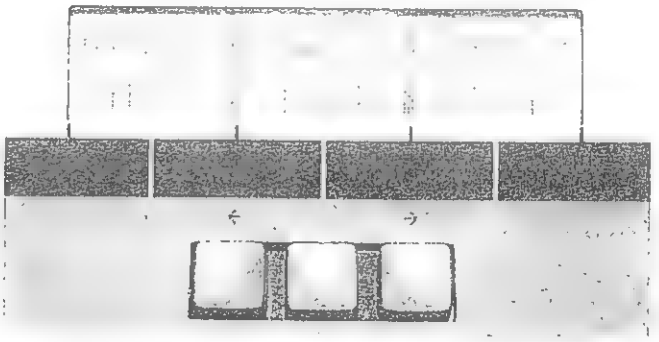
    A. The self-test functionally checks the 5440A through three functions: digital test, analog test, and high voltage test.



53. **Q. How do I perform self-test?**

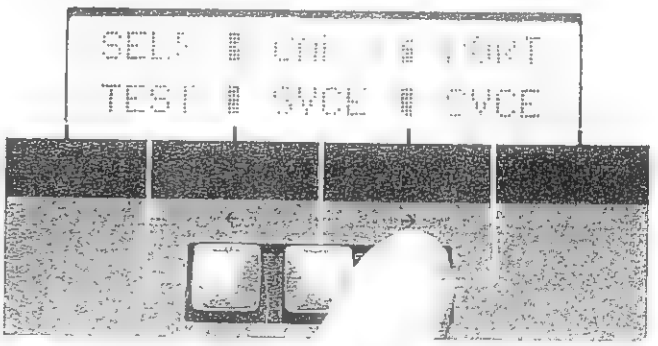
    A. Select SVCE and press the SELF-TEST soft key. Three options appear:

    1) DIGITL TEST verifies the primary digital circuitry. "PERFORMING DIGITAL SELF-TEST ... WAIT" appears on the alphanumeric display. The 5440A displays any detected error or returns to VOLTAGE MODE on successful completion of the test.
    2) ANALOG TEST first asks the operator to "REMOVE OUTPUT LEADS & DO ANALOG TEST?" Then it tests the analog circuitry and ovens. The instrument performs a sequential check of analog circuitry and displays on the front panel what modules are being tested. Test-point voltages may be listed on an external RS-232-C printer.
    3) HIGH V TEST checks the high voltage analog circuitry.



54. **Q. How do I list test-point voltages?**

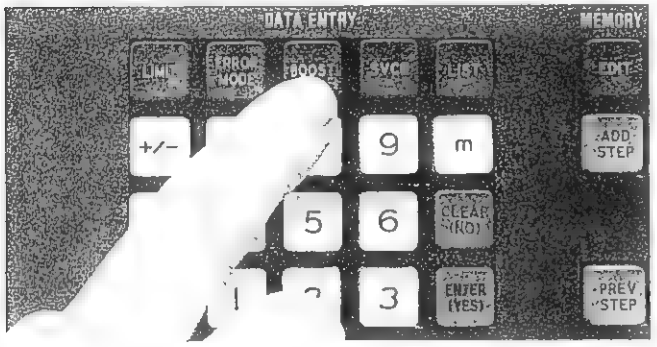
    A. Before initiating self-test select SVCE and press PORT SVCE, MONIT ON/OFF, and MONIT ON. The 5440A sends the data to a printer or monitor automatically.



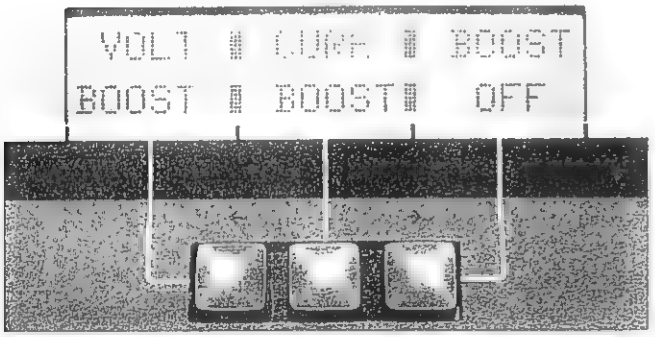
Boost

45. **Q. What does the BOOST key do?**

A. The BOOST key accesses 3 operating modes of the 5440A via the soft keys:



1) BOOST OFF sets the instrument to its default voltage mode.
2) VOLT BOOST sets the 5440A to the voltage boost mode.
3) CURR BOOST sets the 5440A to the current boost mode.



46. **Q. What is voltage boost mode?**

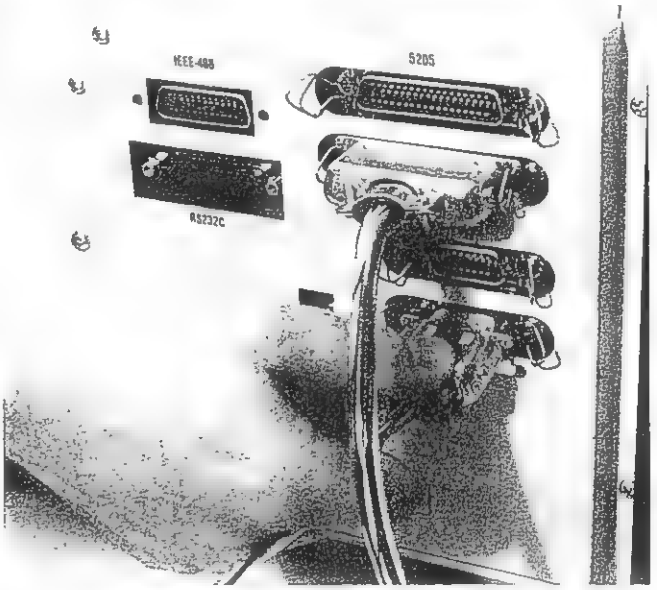
A. Under voltage boost mode, a Fluke 5205A Precision Power Amplifier can be connected to the 5440A to produce high voltages (up to 1500V @ 100 mA).

47. **Q. What is current boost mode?**

A. Under current boost mode, a Fluke 5220A Transconductance Amplifier can be connected to the 5440A to produce high currents (20A).

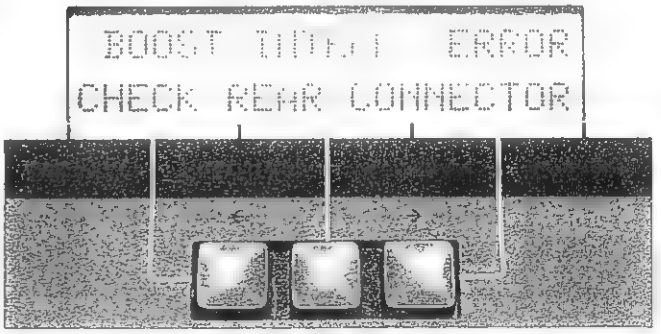
48. **Q. How do I connect the boost instruments?**

A. The 5440A contains both digital and analog interfaces for the 5205A and 5220A. When Fluke model Y5001 or Y5002 cables are connected, the 5440A recognizes the instruments.



49. **Q. What happens if I access the boost mode and the boost instrument is not present?**

A. The alphanumeric display responds with "BOOST INTERF ERROR CHECK REAR CONNECTOR."

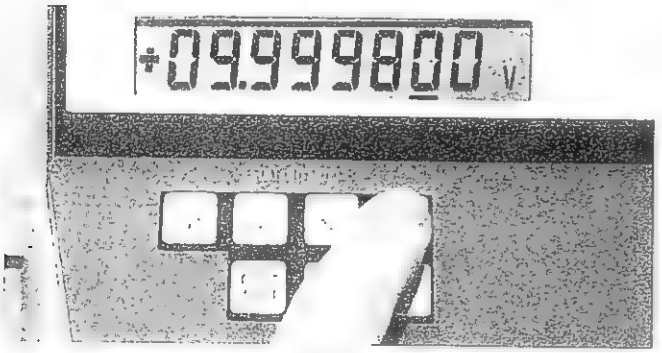


50. **Q. Where do I access the boost output?**

A. Each boost instrument has its own output terminal. The 5440A, however, displays the voltage or current value.

41. **Q. What do the left / right arrow buttons under the output display do?**

A. The left / right arrow moves the underline output cursor left or right. Therefore any output digit can be easily modified.



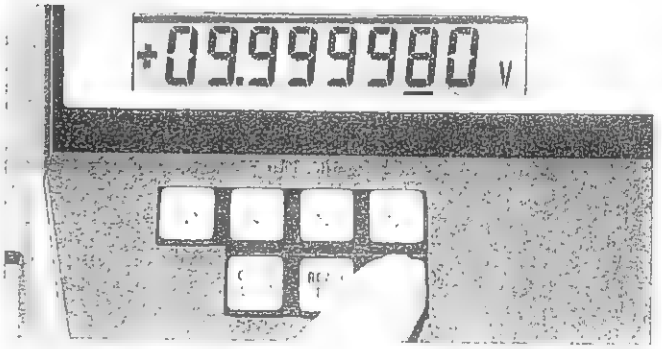
42. **Q. What does the CHNG SIGN edit output button do**

A. The CHNG SIGN button reverses the polarity of the output value (the operator may also enter the negative of the displayed output value via the keyboard).

43. **Q. What does the NEW REF edit output button do?**

A. The NEW REF button defines the displayed output value as the nominal reference. For example, if the user wishes to compare two UUT's the first can be set to some reading and NEW REF defines that value as the reference; when the second UUT is set to the same reading the alphanumeric display shows the error between the two instruments.

The nominal reference is set automatically when a user enters an output voltage through the keyboard.



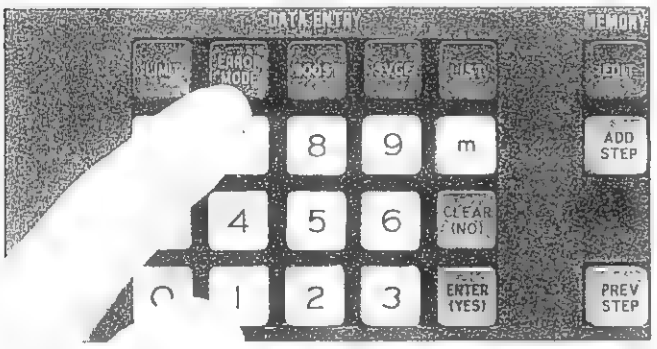
44. **Q. What does the RCALL REF edit output button do?**

A. The RCALL REF button sets the output value to the nominal reference.

Error Mode

37. **Q. What is the purpose of the error mode?**

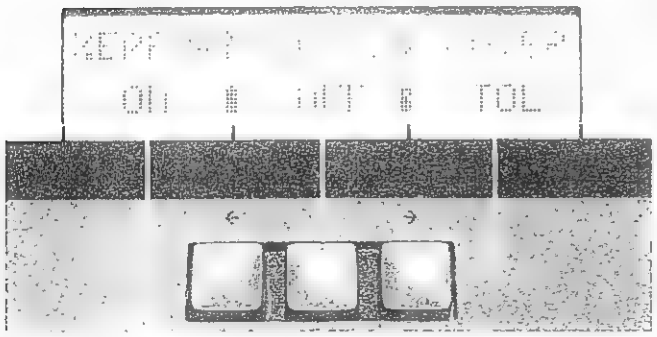
    A. The error mode computes the deviation from nominal of the UUT and displays it on the alphanumeric display. A PASS or FAIL indicator appears when tolerance limits are enabled.



38. **Q. What are the choices of error mode display?**

    A. The ERROR MODE key enables three soft keys:

    1) %ERROR OFF turns off %error display.
    2) %ERROR ON enables %error/PPM display and shows the deviation from nominal value for the UUT. Deviations less than 1000 ppm are shown in ppm; deviations over 10000% are shown as 9999.9%.
    3) ENTER TOL allows the operator to select a tolerance specification as a % of output + floor. The display shows ppm or % error deviation and a PASS or FAIL message.



39. **Q. How do I convert a typical tolerance spec to %error + floor?**

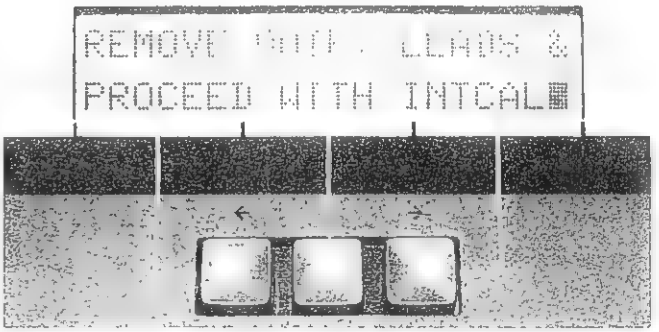
    A. If the UUT specification is 0.001% of input plus 0.001% of range on the 10V range then the floor can be converted from the range value: 0.001% of 10V is 100 μV. Therefore the tolerance may be entered as follows:

    ERROR MODE
    ENTER TOL
    . 0 0 1
    (press the center soft key)
    1 0 0
    ENTER(YES)

Error Mode Output Edit

40. **Q. What are the up / down arrow buttons under the output display used for?**

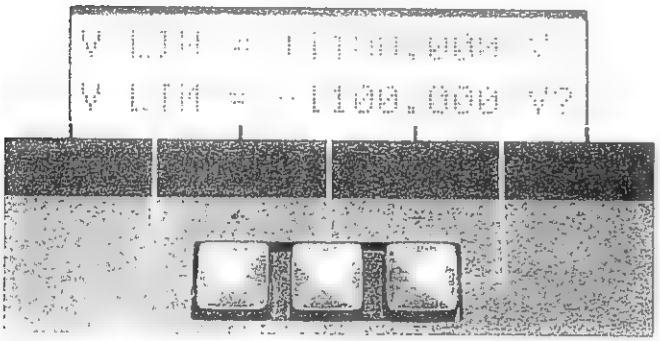
    A. The up / down buttons increment or decrement the underlined output digit by one. Pressing the up button five times increments the output digit by 5; holding the up arrow button increments the output continuously about every half second. The edit output buttons modify the UUT reading or null the output during external calibration. The maximum individual increment is 100V or 1A.



Voltage Limits

30. **Q. What does the voltage limit do?**

    A. The programmed voltage limits prevent damage to a load through operator error. For example, if the voltage limit is set for 110 volts and the operator attempts to increment the output from 100 to 200 volts, the output remains at 100 volts and an error message informs the operator that the entry is out of range.



31. **Q. How do I set the voltage limits?**

    A. Press LIMIT, then the "VOLT LIMITS" soft key. The numeric keys edit the displayed limit levels which are selected by pressing ENTER(YES).

32. **Q. What about negative voltage limits?**

    A. To set negative voltage limits, press LIMIT then "VOLT LIMITS." The center soft key moves the cursor to the negative limits line. Negative voltage limits can be set differently from positive limits. For example, to enter limits of +100V and −50V:

    LIMIT
    VOLT LIMITS
    1 0 0
    (press the center soft key)
    5 0
    ENTER(YES)

33. **Q. What does the voltage monitor do?**

    A. The 5440A contains an internal analog-to-digital converter (a-d) which periodically monitors the output voltage. If the measured voltage differs more than 5% from the programmed voltage the 5440A returns to standby and an error message appears on the alphanumeric display. This monitor does not test for accuracy; it functionally checks the instrument and serves as a safety monitor.

34. **Q. Does the instrument go to standby if the voltage is too low as well as too high?**

    A. Yes, the 5440A is set to standby and the message "UNDERVOLTAGE" appears on the display.

35. **Q. Is there a delay on the voltage monitor similar to that of the current monitor?**

    A. Yes, the monitor delays four seconds following any programmed change in output voltage or following a change from standby to operate.

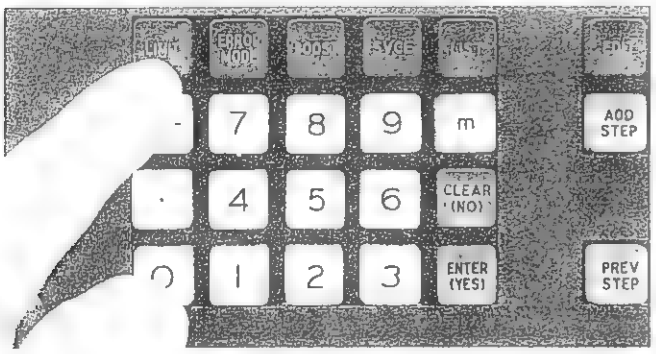
36. **Q. Why does a shorted output result in an "UNDERVOLTAGE" error message instead of an "OVERCURRENT" message?**

    A. The monitor circuit alternately monitors output current and output voltage. Depending on when the short circuit occurs, the next monitor function may be for voltage or current and either overcurrent or undervoltage (caused by current limiting) produces a shut-down.

Limits

24. **Q. What does the LIMIT button do?**

    A. The LIMIT button accesses secondary functions associated with voltage or current limits.

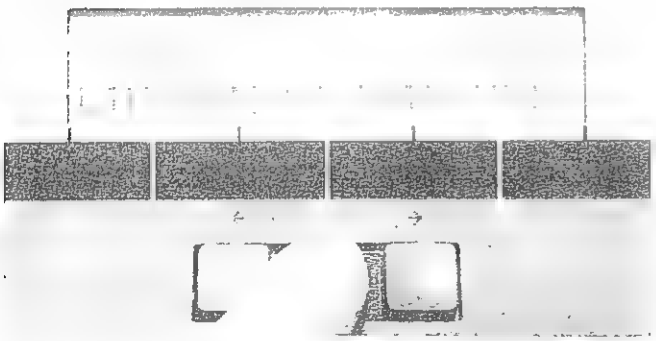


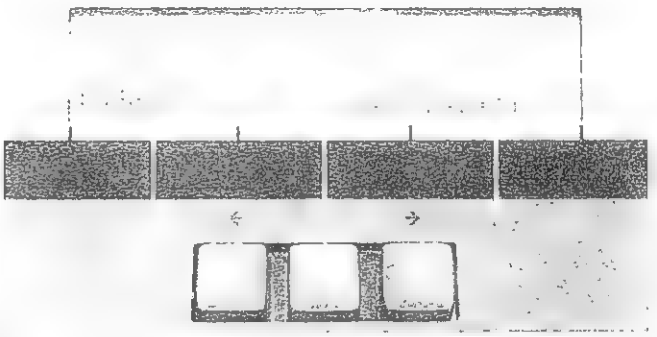
Current Limits

25. **Q. How do I set current limits?**

    A. Press the LIMIT key, then the center soft key for "CURR LIMITS." The alphanumeric display shows the default limits (25.0 mA) and the blinking digit indicates which number can be edited. To store new limits, press ENTER. For example, to enter a current limits of 10.5 mA the following keys would be pressed:

    LIMIT
    CURR LIMITS
    1 0 . 5
    ENTER





26. **Q. What about current limits for negative output voltage?**

    A. The current limit setting is the same for both polarities.

27. **Q. If I set the current limit to 10.0 mA will the equipment I connect to the output terminals be protected against any overcurrent of more than 10.0 mA?**

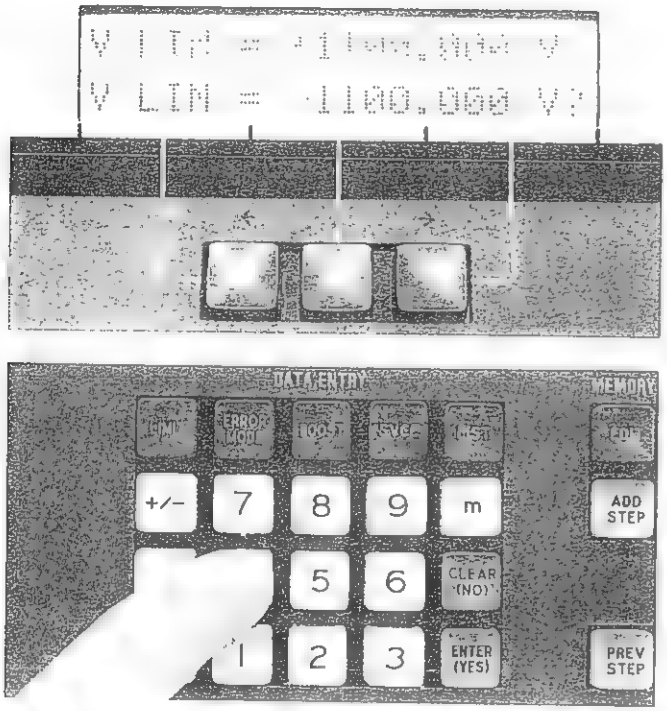
    A. Not exactly. If the load impedance and the output voltage are such that more than 10.0 mA would result, the output current momentarily exceeds 10.0 mA. The 5440A detects the overcurrent and switches to standby after a programmed delay.

28. **Q. What is the maximum output current?**

    A. The maximum transient output current is about 55 mA (it is dependent upon the load impedance and output voltage). This value is set by fixed current limiting circuitry in the 5440A.

29. **Q. And how long is the programmed delay?**

    A. A four-second delay follows any programmed change in the output voltage. During this time the current monitor is inoperative. The delay allows output settling and capacitor charging time. After four seconds the monitor circuit begins sampling the output current at one second intervals. If the current exceeds the programmed limit the 5440A returns to standby.



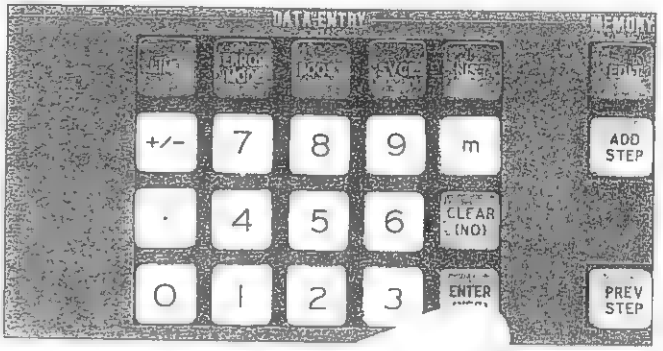
21. **Q. How are numbers entered for parameter changes?**

    A. When the user selects a function with a parametric value, the 5440A displays the present value. If the operator presses a digit, dot, ± or m then the displayed value is zeroed out. New entered digits appear under the blinking cursor. The two outer soft keys move the cursor and allow the user to change digits. When two entry fields are displayed, the center soft key toggles the cursor to the first digit of the other field.

    When enabled, the ± button toggles the sign of the entry between + and −. When enabled, the m button toggles between milli and micro or between milli and blank multiplier.

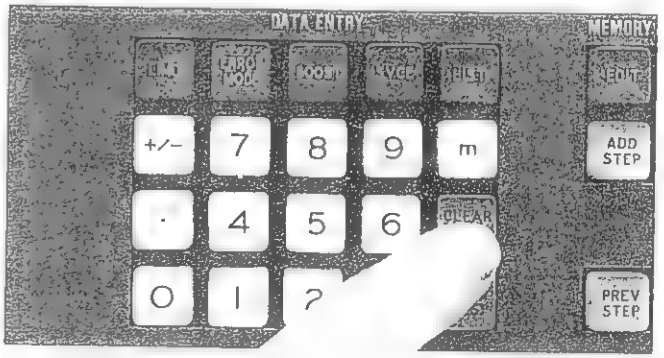
22. **Q. What does ENTER(YES) do?**

    A. ENTER(YES) selects the displayed value as the new parameter. It also answers YES when prompted for verification or operator action.



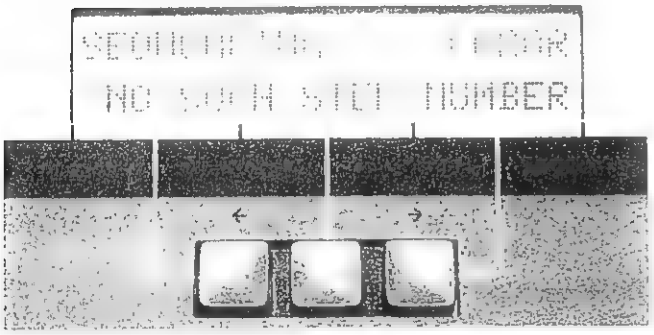
23. **Q. What does CLEAR(NO) do?**

    A. CLEAR(NO) cancels the keyboard entry. It also answers NO to prompts and clears error messages appearing on the display.



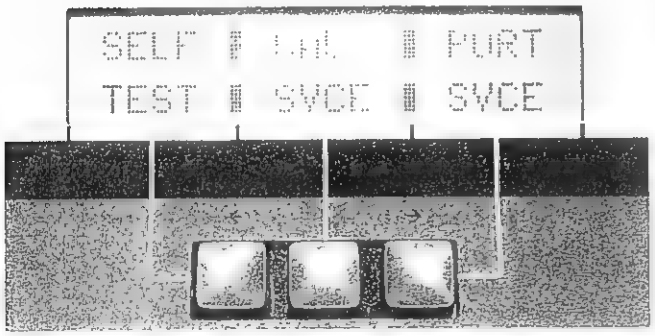
17. **Q. How are user errors or instrument faults indicated?**

A. A major hardware failure lights a red FAULT indicator on the front panel. RESET attempts to restart the instrument. User errors or instrument hardware faults are indicated on the alphanumeric display. The top line shows the error or fault type while the bottom line includes specific fault information or a suggested course of action. The instrument clears error messages when the operator presses any button.



18. **Q. What are soft-labelled keys?**

A. Soft-labelled keys are the top 3 unlabelled buttons just below the alphanumeric display. Each key changes functions as defined by segments of the alphanumeric display.



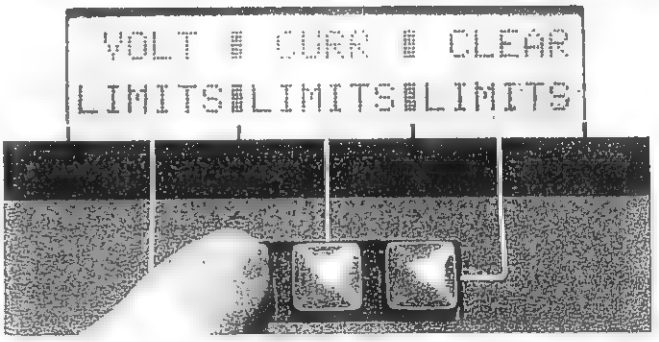
19. **Q. How do I access secondary or seldom-used functions?**

A. Approximately 30 secondary functions are accessed through the soft keys. The user selects one of 7 categories labelled LIMIT, ERROR MODE, BOOST, SVCE, LIST, EDIT, and XFR. Each of these selections displays further choices on the alphanumeric display.

Parameter View and Data Entry

20. **Q. How are instrument parameters viewed and entered?**

A. The 5440A uses arithmetic notation for parameter value viewing and entry. First select one of the 7 categories (e.g. LIMIT) and touch a soft key (e.g. VOLT LIMITS). Then press keyboard digits to change the numeric value on display. ENTER sets the parameter to the displayed value and CLEAR leaves the parameter unchanged.



5440A Operation

Output Display

15. **Q. What does the output display show?**

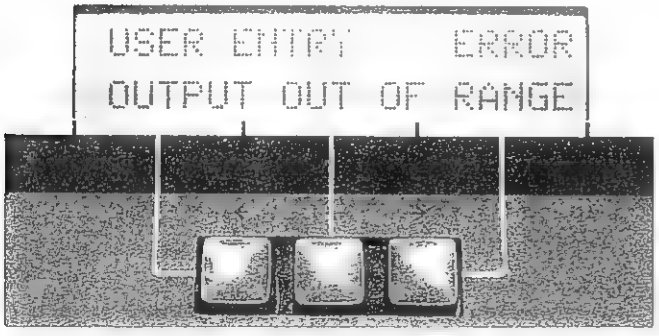
A. When in voltage mode, the output display shows the voltage present at the sourcing terminals when OPR (operate) is selected. When in boost mode, it shows the output of the boost instrument.

Alphanumeric Display

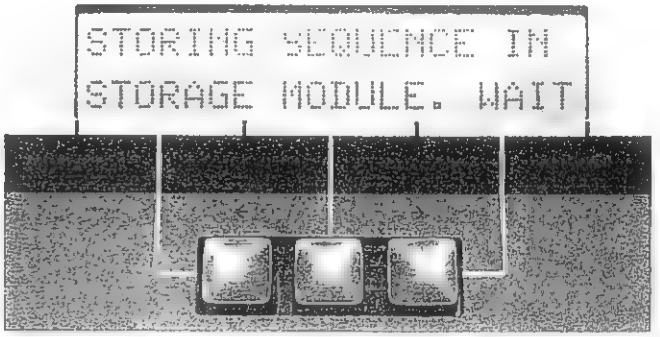
16. **Q. What does the alphanumeric display show?**

A. The alphanumeric display performs one of four functions:

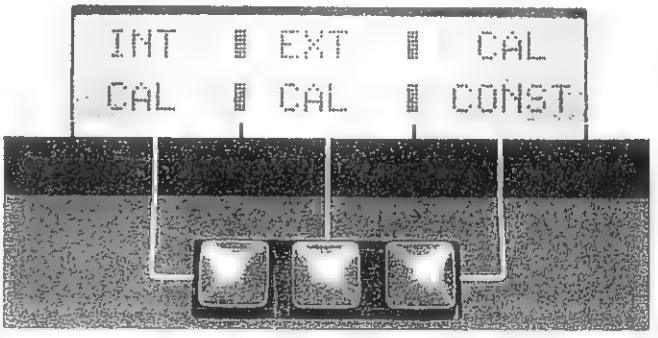
1. Highest priority is for displaying hardware fault or user error messages which can be cleared by pressing any button.



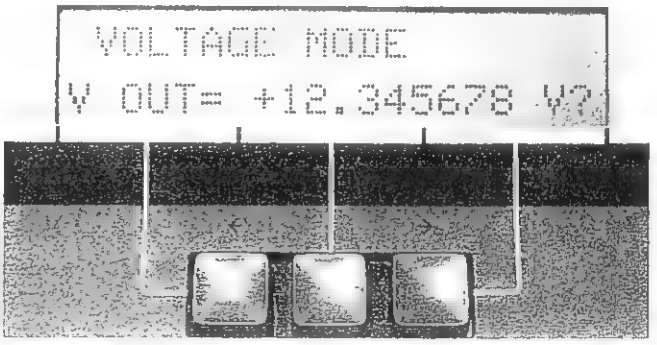
2. It informs the operator of long-term instrument activity.



3. It defines the function of unlabelled keys through 3 "soft-labels" of two rows of 6 characters each.

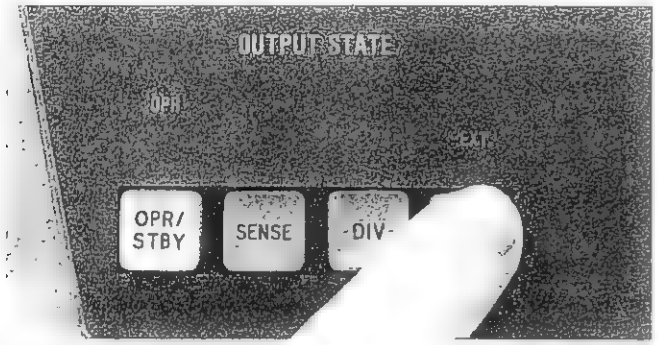


4. It displays the present value of some parameter and prompts the operator for numeric entry.



10. **Q. What does the GUARD button do?**

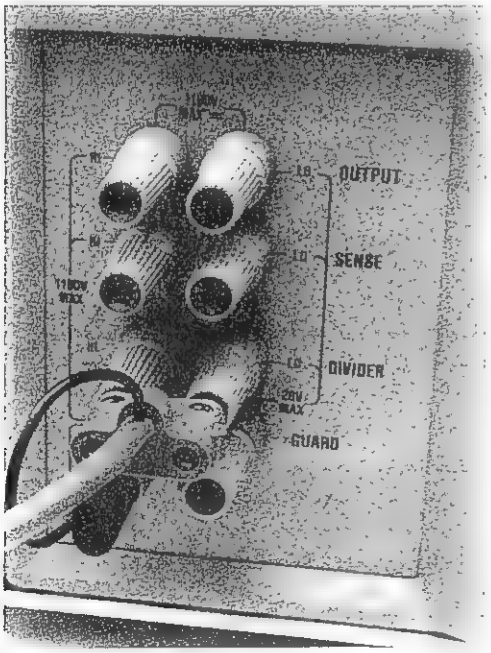
A. GUARD toggles between guard shorted to low (INT GUARD) and guard left floating for external connection.



Divider Output

11. **Q. What is the DIVIDER output terminal?**

A. The 5440A contains an internal 10:1 and 100:1 voltage divider which improves the resolution and noise characteristics of the instrument.



12. **Q. How much current can be drawn from the divider output terminals?**

A. The divided output terminals have an output impedance of 450 ohms on the 2 volt range and 495 ohms on the 0.2 volt range. Therefore any current drawn will degrade the accuracy of the divided output voltage. Divided output is suitable for calibrating high impedance voltmeters only.

13. **Q. How much will the accuracy be degraded by connecting a meter with, for example, 10 megohms input impedance to the divided output terminals?**

A. The error is equal to the output impedance divided by the shunting resistance. If the 2.0 volt range is used where output impedance is 450 ohms, the error will be 450/10M = −45 ppm. On the 0.2 volt range where the output impedance is 495 ohms, the error would be −49.5 ppm.

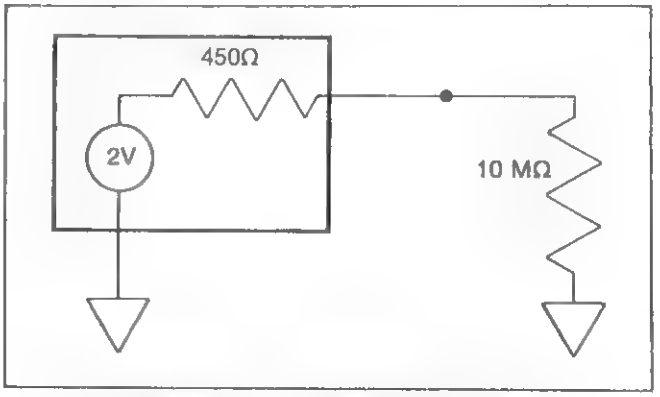


Figure 3: Loading of the Divider Terminals

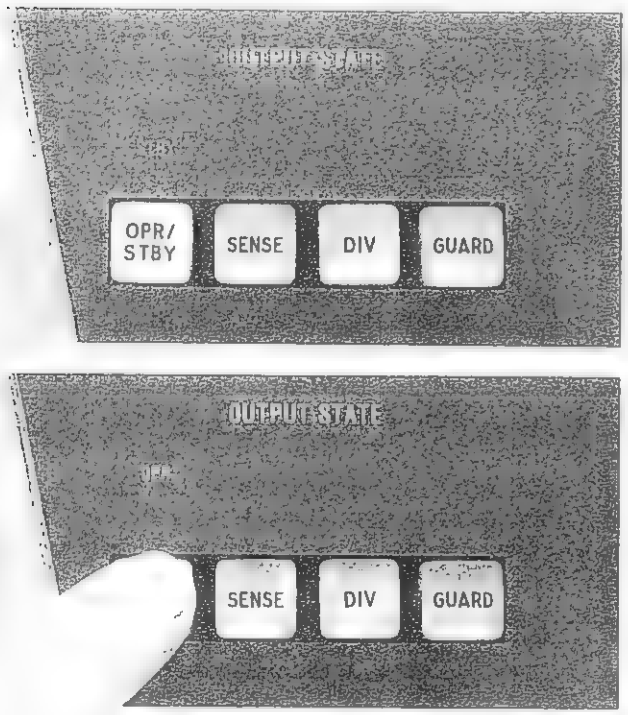
14. **Q. If the divided outputs introduce that much error, why are they used?**

A. Most high accuracy meters have much greater input impedance than the 10 megohms used as an example. Typical input impedance for a high accuracy meter on the low ranges is 1000 megohms or more. This value reduces the error to 0.45 ppm. Meters which have lower input impedance are usually lower accuracy. For calibrating low input impedance meters it is best to use the normal output terminals which have very low output impedance.

Output Terminal State

6. **Q. What does the OPR/STBY button do?**

   A. OPR/STBY toggles the state of the output sourcing terminals between operate and standby as indicated by the LED above the key. When in operate, the voltage on the output display is present at the sourcing terminals.

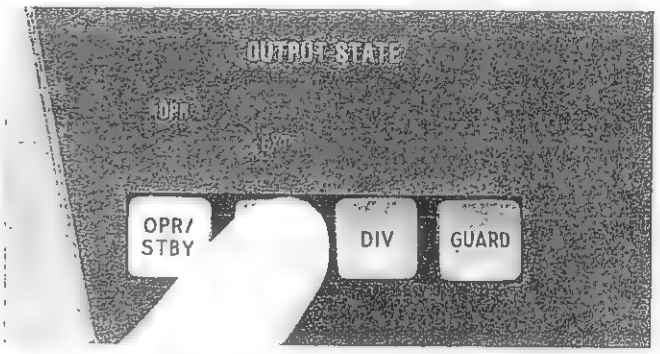


7. **Q. What is standby?**

   A. Standby is the power-up/reset condition of the 5440A. In this condition, the front panel SENSE HI and OUTPUT HI are disconnected from the active internal circuitry as a safety precaution to the user. In standby the output is still connected to a one microfarad capacitor in parallel with a 1 Mohm resistor. Therefore, during high voltage operation the output may take up to three seconds to drop to a safe condition after the unit has been placed in standby.

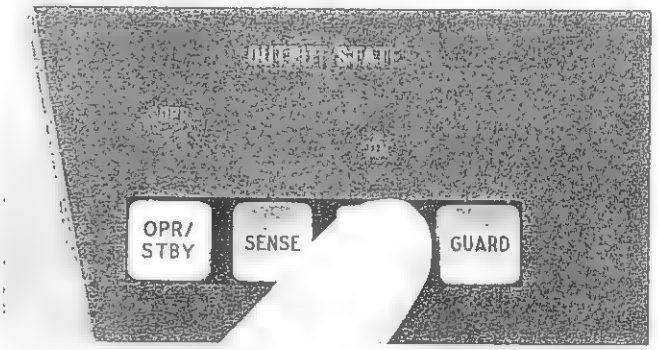
8. **Q. What does the SENSE button do?**

   A. SENSE toggles between internal sensing and external sensing. When the EXT sense LED is on, special sensing circuitry compensates for lead losses. This proprietary circuit is called HZs(TM) and corrects for up to 2 ohms in the sense leads.



9. **Q. What does the DIV button do?**

   A. DIV toggles the selection of sourcing terminals between divider output (DIV ON) and normal output for voltages of less than 2.2V. The divider output improves resolution and noise characteristics and has an output impedance of about 500 ohms.



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Turn-On Status

1. **Q. What happens when I turn the instrument on?**

   A. The power-on circuitry activates the front-panel LEDs and each microprocessor performs a quick self-test. Then the LEDs turn off and all output display segments are turned on. About a second later the rear microprocessor becomes operational and only the STBY LED is on; the output display shows "+00000.000mV" and the alphanumeric display shows "VOLTAGE MODE."

2. **Q. What are the default power-up instrument settings?**

   A. Voltage mode, standby, internal sense, internal guard, divider off with 00000.000mV output. Voltage limits of +1100V and −1100V, current limit of 25 mA.

Reset

3. **Q. What does the RESET button do?**

   A. RESET initializes the 5440A to its power-up default settings and aborts long tasks (e.g. external calibration, internal calibration, self-test or printing). The software version number flashes on the alphanumeric display. Steps in sequence memory are not modified.

Voltage Output

4. **Q. How do I output 10.000000 volts dc?**

   A. With the display showing "VOLTAGE MODE", enter 1, 0. The second line of the display will ask "V OUT = + 10.000000 V?" Verify the value by touching ENTER. The output display now reads +10.000000V. To output the voltage at the terminals press OPR/STBY. The STBY LED changes to OPR and 10.000000 volts appears at the OUTPUT terminals.

5. **Q. Suppose I mistakenly enter 100 volts instead of 10 volts. Does the 5440A provide any high voltage protection due to key error?**

   A. To obtain voltages at the output, the user must activate the OPR button on the front panel. In addition, if the user tries to obtain voltages greater than 22 volts when the instrument is in the operate condition at a level below 22 volts, the 5440A trips into standby. The user must then press OPR. If the 5440A is in the operate mode above 22 volts, then the unit remains in operate. Voltage limits provide additional protection against erroneous user entries.

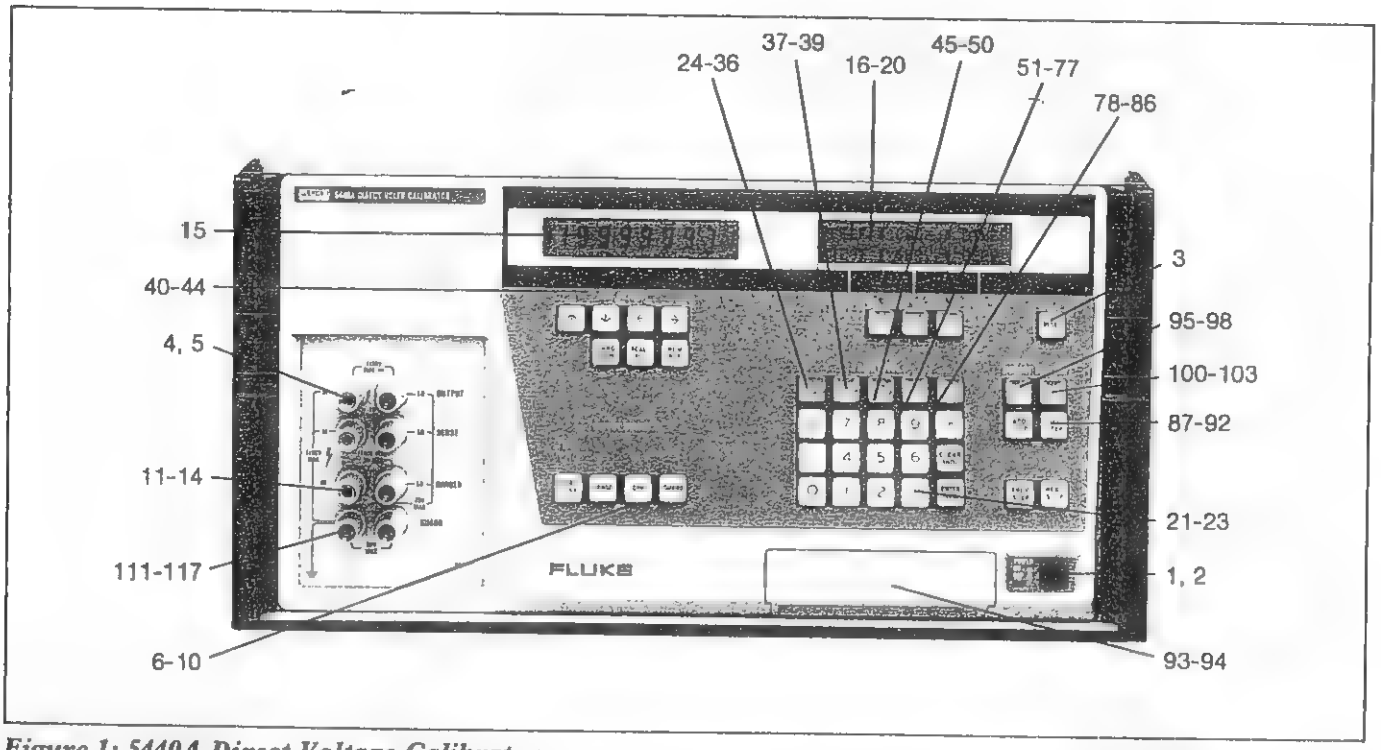

Figure 1: 5440A Direct Voltage Calibrator

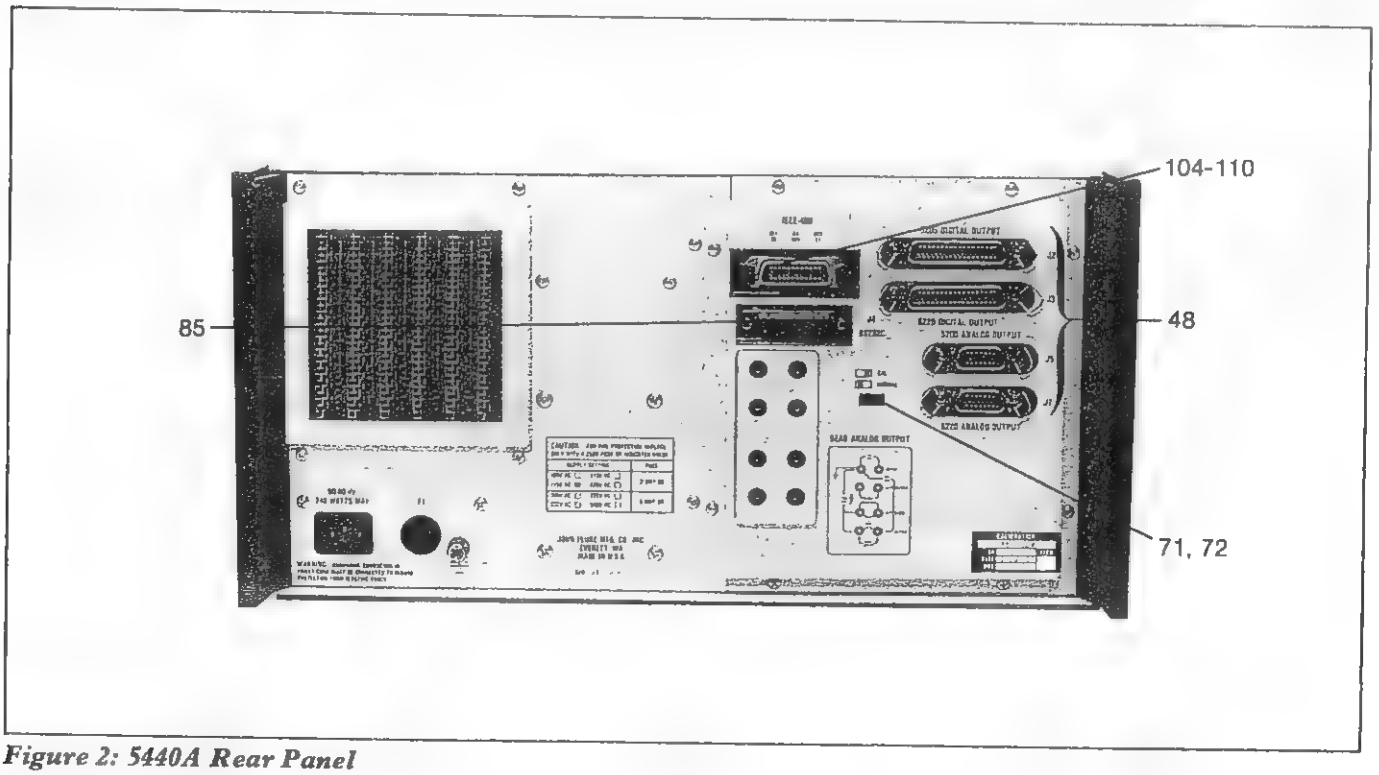

Figure 2: 5440A Rear Panel

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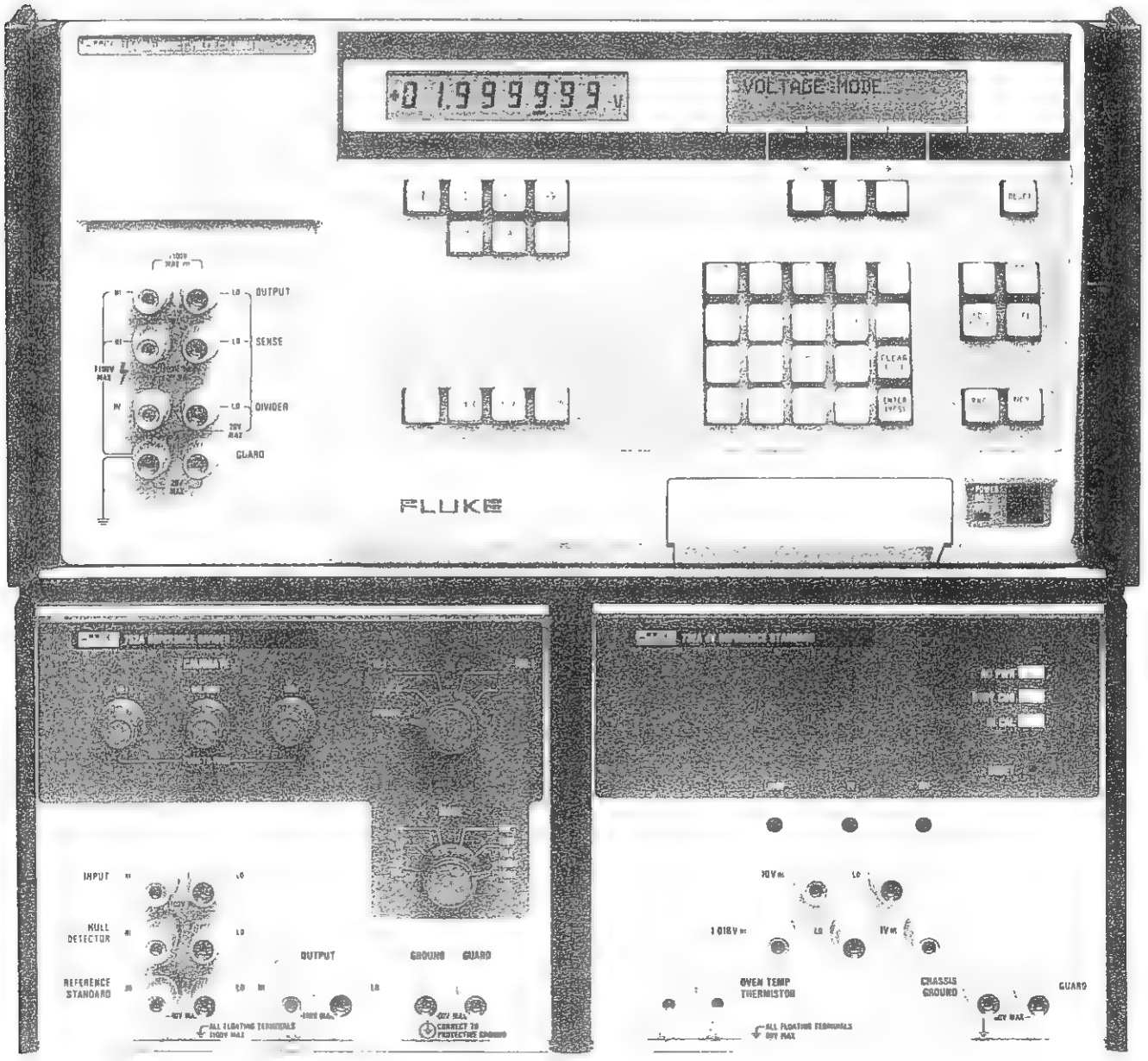
Technical Data

Calibration Dialog B0152

Questions and Answers on the 5440A/732A/752A Precision Direct Voltage Calibration System

This bulletin answers commonly-asked questions concerning the Fluke 5440A Direct Voltage Calibrator, 732A DC Reference Standard, and 752A Reference Divider. Questions are referenced through the callouts on photographs of the instruments. Topics are arranged according to the major functional areas. In addition, photographs of the alphanumeric display of the 5440A assist the reader in locating specific application questions.

This document offers a thorough introduction to the 5440A, 732A, and 752A and provides a quick review for the experienced user.



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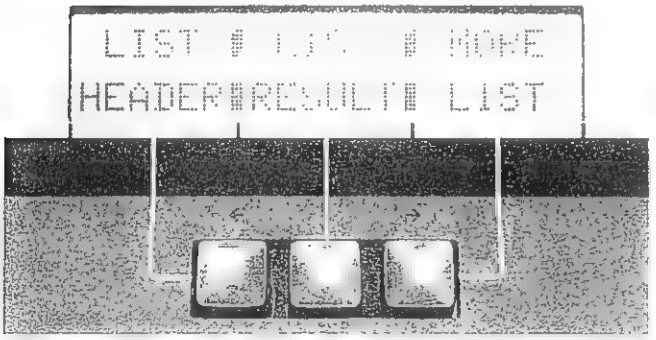
List

78. **Q. What does the LIST key do?**

A. The LIST button selects one of four output options for the RS-232-C port:
1) List header for results.
2) List results of a calibration step
3) List the calibration sequence in memory
4) List the calibration constants



79. **Q. How do I print the results of a calibration test?**

A. Select LIST and press LIST RESULT.

80. **Q. What information is printed in a 5440A UUT Results listing?**

A. Table 3 illustrates a sample results listing. It includes actual voltage output, the reference voltage, the tolerance for that test, and the error information. If the test fails the word FAIL appears in the right margin. The header allows the user to include the date, operator name, instrument type, serial number, and other information on the test report.

JOHN FLUKE MFG. CO., INC. 5440A UUT RESULTS

DATE. OPERATOR.

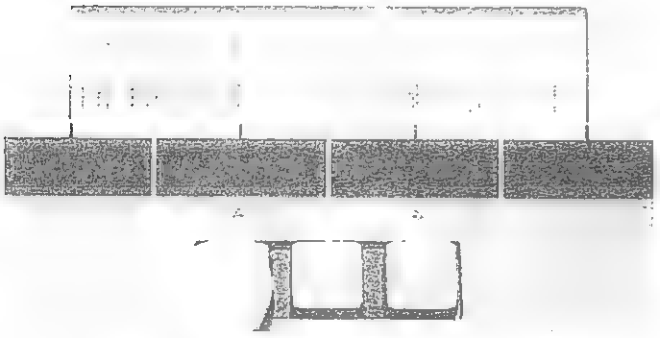
INSTRUMENT SERIAL NO.

STEP	OUTPUT	REFERENCE	TOLERANCE SPEC	% ERROR	
01	+1.0000012 V	+1.0000000 V	+.00100%+2.000uV	-1.2000PPM	
02	+12.000200 V	+12.000000 V			
03	+13.000030 V	+13.000000 V		-2.3000PPM	
04	+14.022340 V	+14.000000 V	+.00100%+2.000uV	-.15957%	FAIL
05	+15.005000 V	+15.000000 V	+.00100%+2.000uV	-333.30PPM	FAIL

Table 3. Printed Listing of 5440A UUT Results

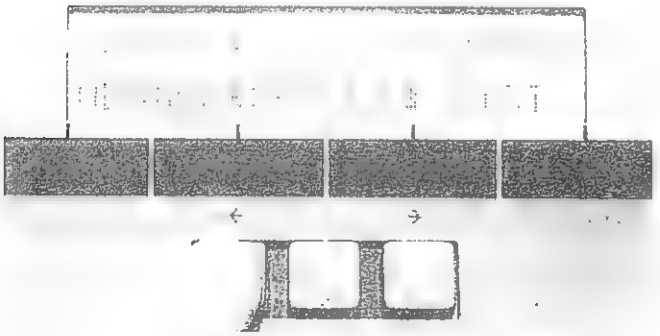
81. **Q. How do I print a 5440A Procedure Sequence?**

A. Select LIST and press MORE LIST followed by the LIST MEMORY soft key. The 5440A sends to the printer the step number, output, limits, and instrument state (see Table 4).



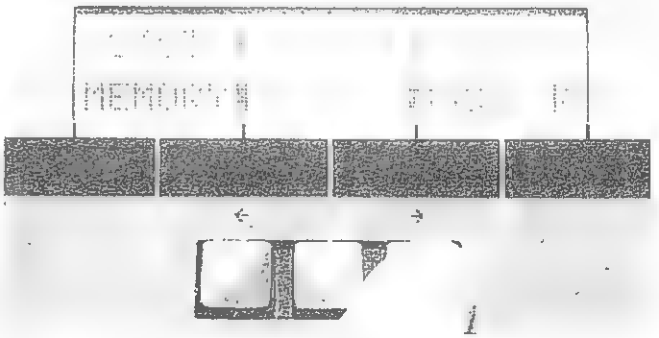
82. **Q. Can I list just the header information?**

A. Yes, select LIST and press LIST HEADER.



83. **Q. You mentioned earlier that I can list calibration information and test point data. Do I use the LIST key for that data?**

A. To list calibration constants select LIST and press MORE LIST and LIST CAL K. Table 5 illustrates the 5440A Calibration Data. However, the test point data and internal calibration data must be listed while the activity is occurring.



JOHN FLUKE MFG. CO., INC. 5440A SEQUENCE LISTING

DATE OPERATOR

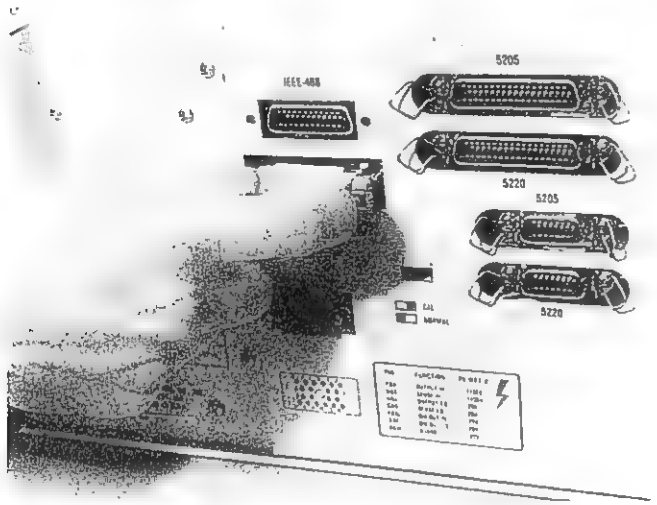
STEP	OUTPUT	LIMITS	STATE
01	+1.0000000 V	+2.0000000 V -2.0000000 V +5.00mA	STBY DIV TOL SPEC:+.00100%+2.000uV
02	+12.000000 V	+100.00000 V -100.00000 V +20.0mA	STBY
03	+13.000000 V	+100.00000 V -100.00000 V +20.0mA	OPER EXTGRD % ERROR ON
04	+14.000000 V	+1100.0000 V -1100.0000 V +25.0mA	OPER TOL SPEC:+.00100%+2.000uV
05	+15.000000 V	+1100.0000 V -1100.0000 V +25.0mA	OPER EXTSNS TOL SPEC:+.00100%+2.000uV

Table 4. Printed Listing of 5440A Calibration Memory Sequence.

Printer Port

84. **Q. Can I connect my RS-232-C printer to the 5440A?**

    A. Yes. The printer port uses standard ASCII codes. The 5440A allows a wide range of BAUD rates up to 9600 BAUD. The BAUD rate is set from the front panel or the IEEE 488 interface and is stored in non-volatile memory.



85. **Q. What does the message "RS232 SERIAL ERROR" mean?**

    A. The 5440A uses a 5 second per character timeout to detect the presence of a printer. If the 5440A printer port cannot transmit within 5 seconds it cancels printing and displays the error message.

86. **Q. Can I connect an RS-232-C video monitor in place of a printer?**

    A. Yes, in fact the Fluke 1780A Infotouch Display is ideal for this purpose. All data from the 5440A prints on the monitor screen.

JOHN FLUKE MFG. CO., INC. 5440A CALIBRATION DATA

CONSTANT	10V RANGE	20V RANGE	250V RANGE	1000V RANGE
Gain	+.54313609 mV	+1.0862640 mV	+13.577998 mV	+54.311978 mV
2V Gain		+1.0862762 mV		
.2V Gain		+1.0862863 mV		
+Offset	+4.8645389 mV	+9.7681830 mV	+122.47198 mV	+490.39426 mV
-Offset	+5.5948529 mV	+11.149847 mV	+139.00318 mV	+555.53586 mV
Gain Shift	-.0 PPM	-.0 PPM	-.0 PPM	-.0 PPM

Resolution ratio: 7292 A/D gain: +.2813 mV

Table 5. Printed Listing of 5440A Calibration Data

Memory Control

87. **Q. What is the purpose of the sequence memory?**

    A. Sequence memory allows the operator to save front panel settings of 5440A for quick recall at a later time.

88. **Q. What does each step include?**

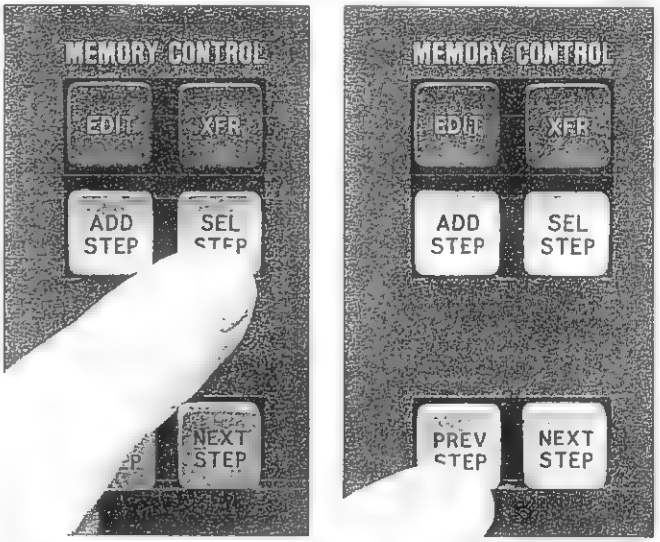
    A. Each step contains the output value (nominal reference), test mode, output state, voltage/current/tolerance limits, and error mode information.

89. **Q. How many steps can be saved in a sequence?**

    A. 60 complete calibration steps.

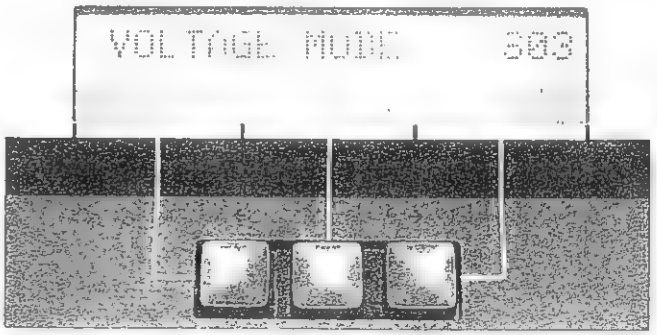
90. **Q. How do I select a sequence step?**

    A. Press SEL STEP, press a step number followed by ENTER. PREV STEP or NEXT STEP quickly advances to the step preceding or following the present step.



91. **Q. How do I know the present step number?**

    A. The present step number appears on the top right of the alphanumeric display. "S" appears before the step number if the step has not been modified.



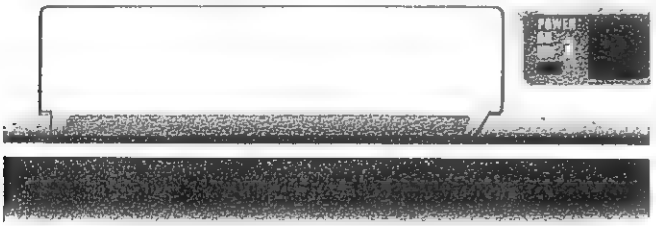
92. **Q. How do I create a sequence of steps to output 1, 2, 3, and 4 volts?**

A. Push 1, ENTER, OPR, ADD STEP, 2, ENTER, ADD STEP, 3, ENTER, ADD STEP, 4, ENTER, ADD STEP.

Procedure Storage Module

93. **Q. What is the storage module?**

A. The storage module is the drawer-like assembly under the front panel keyboard. It contains nonvolatile electronically alterable ROM as a power-off storage media for one sequence of steps. A sequence stored on the module can be transferred to the 5440A sequence memory and vice versa.



94. **Q. How long will the procedure storage module maintain the sequence?**

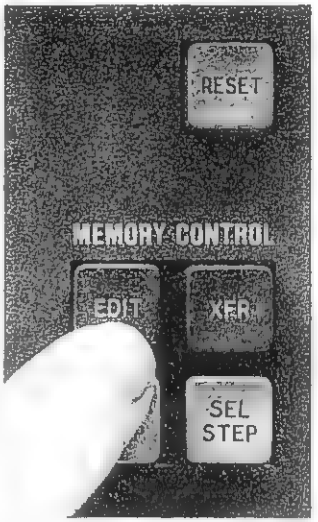
A. The data on the module has a shelf life of at least 10 years. Therefore if the module is not used (e.g. removed from the machine) it will maintain the sequence for a minimum of 10 years.

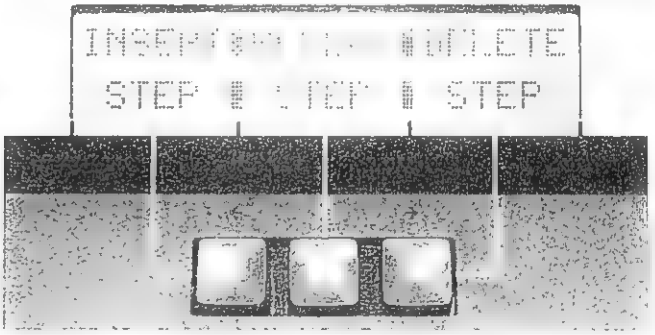
Edit

95. **Q. What does the EDIT key do?**

A. The edit key accesses three functions of the memory control feature of the 5440A:

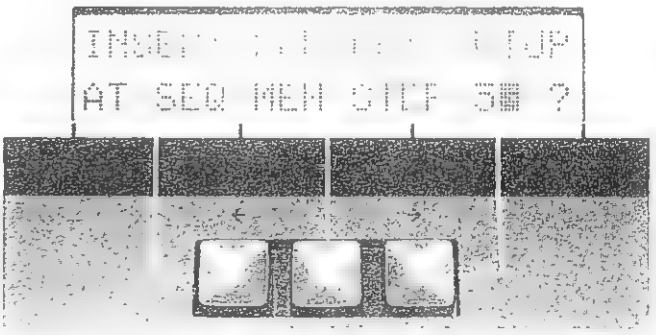
1) Insert calibration test steps into an existing sequence.
2) Replace steps in an existing sequence.
3) Delete steps from an existing sequence.





96. **Q. How do I insert a 10 volt test between steps 4 and 5?**

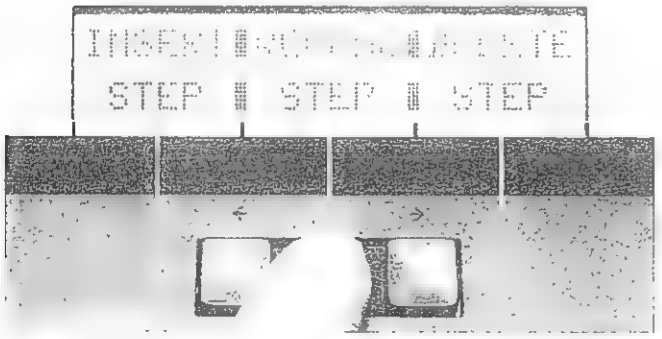
A. Select a 10 volt output from the front panel. Select EDIT and press INSERT STEP. Press 5 followed by ENTER. The old step 5 is now step 6 and step 5 consists of a 10V output.

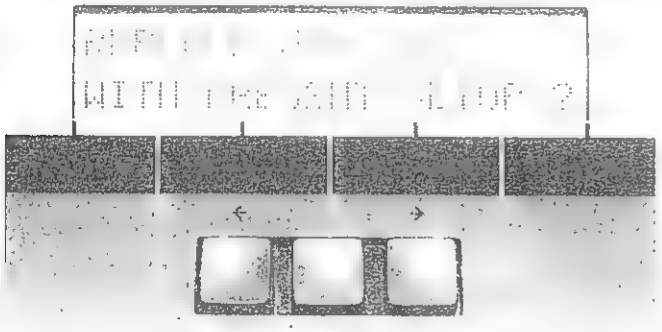


97. **Q. How do I change step 7 to ouput 8 volts?**

A. Press SEL STEP, 7, ENTER to setup the 5440A according to step 7. Press 8, ENTER to ouput 8 volts.

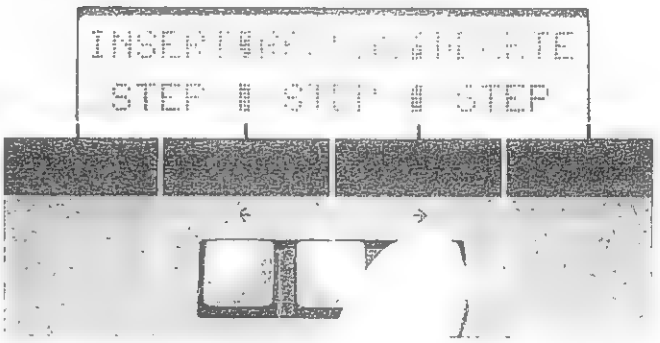
Select EDIT and the REPLAC STEP soft key. Press 7 and ENTER.

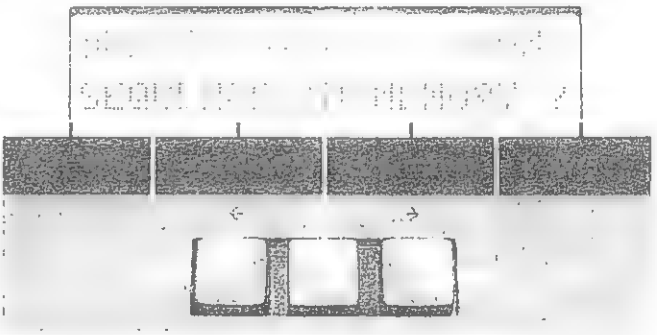




98. **Q. How do I delete step 3 from sequence memory?**

A. Select EDIT and the DELETE STEP soft key. Press 3 and ENTER. Step 4 (if any) is now step 3.





99. **Q. Can the storage module be write-protected?**

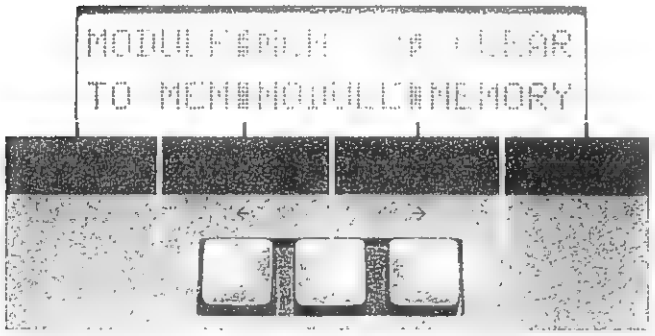
A. Yes, a switch in the storage module protects the stored sequence of steps.

Transfer (XFR)

100. **Q. What does the XFR key do?**

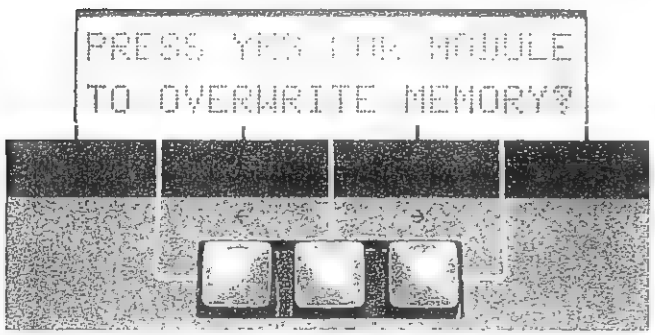
A. The XFR key accesses 3 functions of the Memory Control feature of the 5440A:

1) Transfer a stored calibration sequence from the Procedure Storage Module to the sequence memory of the 5440A (and overwrite memory).
2) Store a calibration procedure in 5440A memory on the Procedure Storage Module (and overwrite any existing procedure on the module).
3) Clear the sequence memory of the 5440A.



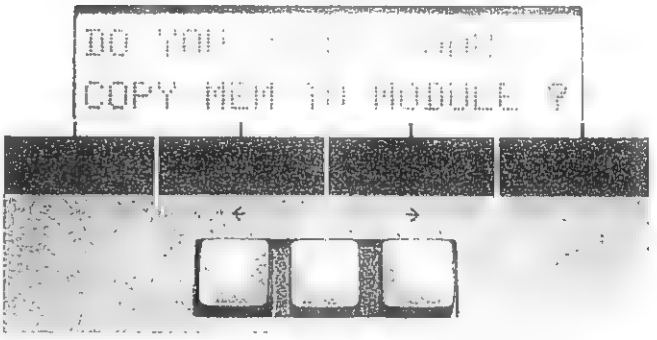
101. **Q. How do I transfer a sequence stored on the module to internal sequence memory?**

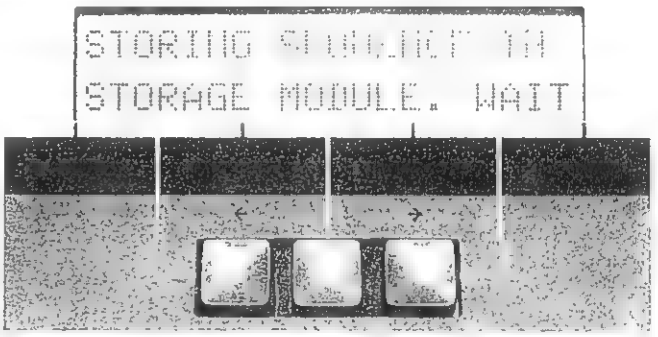
A. Select XFR, press the MODULE TO MEM soft key and answer ENTER(YES) to "PRESS YES FOR MODULE TO OVERWRITE MEMORY?".



102. **Q. How do I write a sequence from internal sequence memory to the storage module?**

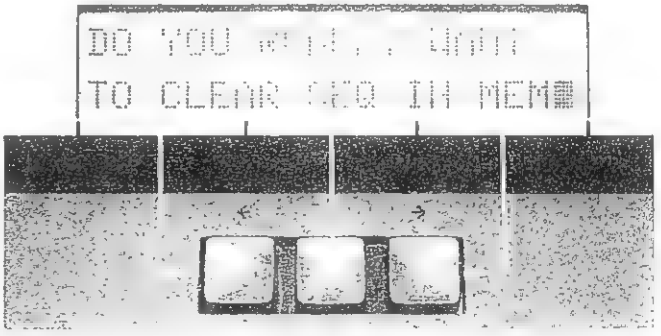
A. Select XFR, press the MEM TO MODULE soft key and answer ENTER(YES) to "DO YOU REALLY WANT COPY MEM TO MODULE?".



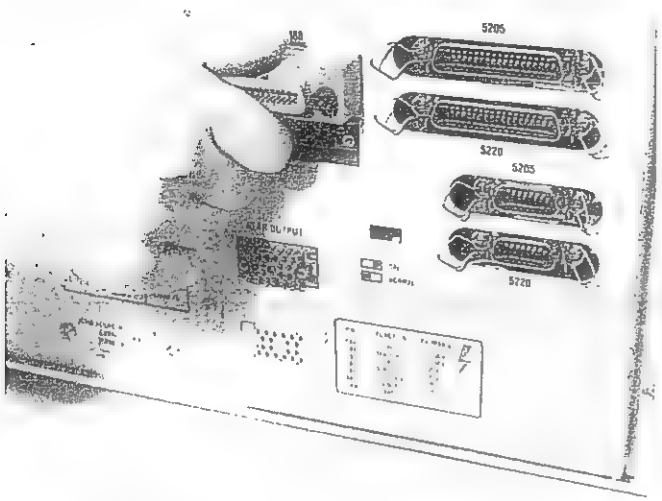


103. **Q. How do I clear internal sequence memory?**

A. Select XFR and press the CLEAR MEMORY soft key. Answer ENTER(YES) to "DO YOU REALLY WANT TO CLEAR SEQ IN MEM?".



IEEE-488 Remote Control



104. **Q. When I'm using the IEEE-488 interface, what messages does the front panel show?**

A. The output display and annunciators display output value and state. The alphanumeric display shows operational mode on the top line and "REMOTE CONTROL" or "REMOTE WITH LOCKOUT" on the second line. Any instrument errors supersede this display.

105. **Q. How do I set the 5440A to local control?**

A. The interface itself determines whether the instrument can be set to local control. If the instrument is in remote control and any button is pushed on the front panel, a "rtl" (return to local) message is sent to the interface. If the interface is not in local lockout, control returns to the front panel.

106. **Q. How are error messages cleared?**

A. Under local control, any button clears an error message. Under remote control, a "GERR" command (get error), "RESET" command or "DEVICE CLEAR" clears both front panel error messages and remote error codes. If an error message is cleared from the front panel, the error code remains available to the remote interface.

107. **Q. Can I control all 5440A functions via the remote interface?**

A. All instrument functions except the power switch are controllable from the remote interface. The only front panel functions not available remotely are list and memory control functions.

108. **Q. Will the 5440A output its status on the bus?**

A. Yes, the 5440A sends a short-form interface status byte, instrument status byte or a long-duration state (e.g. performing self-test).

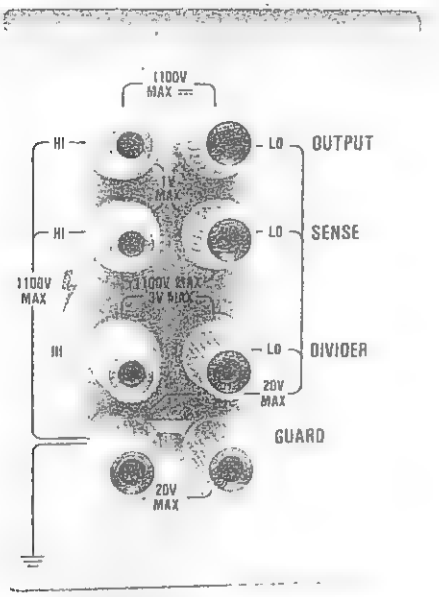
109. **Q. What are the long-duration operations controllable via the bus?**

A. Internal calibration, external calibration, and perform self-test are examples of long-duration operations which can be controlled via the IEEE-488 remote interface.

110. **Q. How would I program the 5440A to output 12.3 volts with a current limits of 23 mA?**

A. "SOUT 12.3; OPER, SCLM 23E-3" tells the 5440A to output 12.3V, go to the operate mode, and set a current limit of 23 mA. The 5440A remote interface is very friendly and easy to use.

Binding Posts and Test Leads



111. **Q. Why does the 5440A have an extra set of binding posts for the divided output?**

A. The divided output utilizes the 20 volt range to produce 2 volt and 0.2 volt ranges through a 10:1 and 100:1 voltage divider. The 0.2 volt range has 10 nanovolt resolution. At such small voltage levels thermals could be introduced by switches. Therefore, rather than having a single output terminal with switching for the divided ranges, the 5440A employs a separate divided output. Note that to use the divided ranges the DIV button must be activated.

112. **Q. What is the purpose of the external sense binding posts?**

A. External sense maintains output accuracy when loads are present at the output. Under external sense the 5440A senses the voltage at the load and prevents the IR voltage drop that would occur through the output leads due to the load.

113. **Q. What about currents in the sense leads?**

A. Although external sense compensates for IR voltage drop through the output leads, small currents do exist in the sense leads. If the resistance of the sense leads is too large, errors result due to the sense lead current.

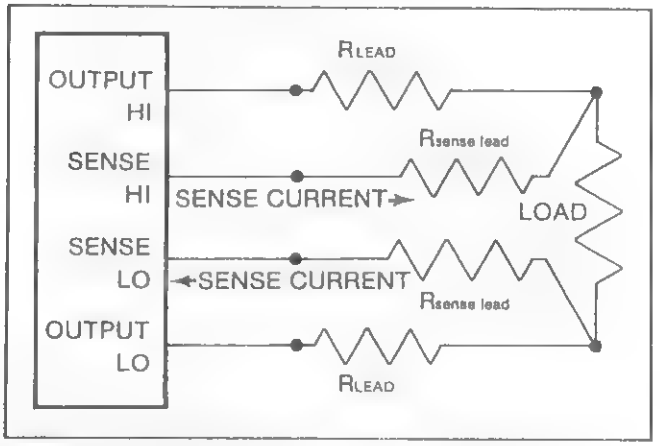


Figure 4. The effects of current in the sense leads.

114. **Q. How much resistance can I have in the external sense leads before the accuracy is affected?**

A. The 5440A contains an internal sense cancellation circuit called HZs(TM) which greatly reduces sense lead current. Therefore relatively large sense lead resistance (up to two ohms) does not affect accuracy. This feature removes a common source of calibration error, especially in large systems.

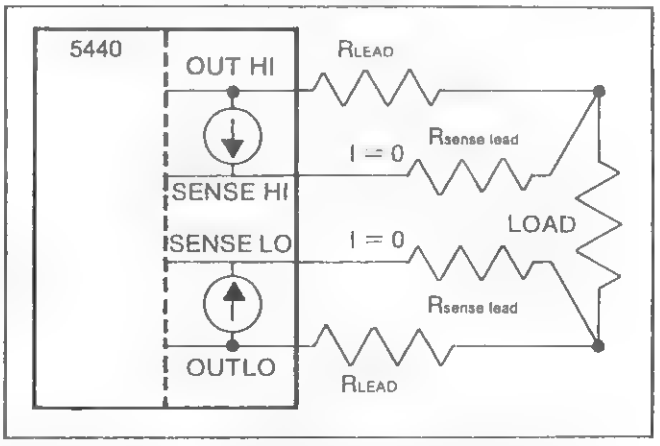


Figure 5. The use of HZs(TM) to eliminate current in the sense leads.

115. **Q. Does external sense operate on the 0.2 and 2 volt ranges?**

A. No, sensing on divided outputs is internal at the input of the 10:1 and 100:1 divider.

116. **Q. How should I connect the guard?**

A. For best performance and common mode rejection ratio, connect the guard to the output low at the unit under test. This connection removes leakage currents through the measurement leads.

117. **Q. What is the default guard state?**

A. The 5440A normal power-up/reset condition connects the guard to OUTPUT LO. Selecting External Guard removes this connection.

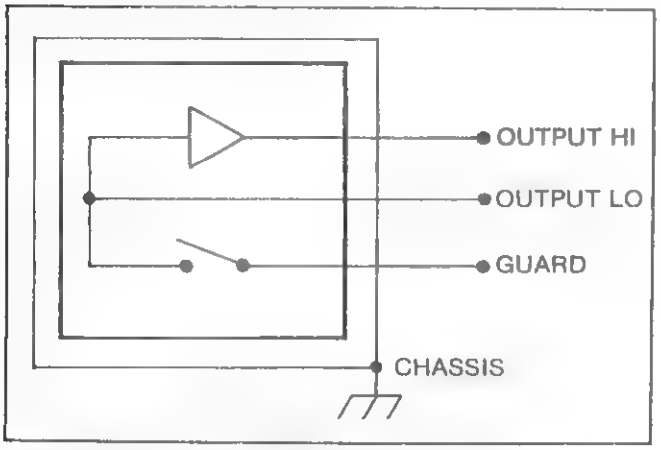


Figure 6. The guard connection on the 5440A

Specifications

118. **Q. Why is the 5440A specified by uncertainty rather than accuracy?**

A. Uncertainty and accuracy are measures of the same specification. Uncertainty is the allowed deviation from nominal. The smaller the uncertainty, the better the calibrator. Accuracy can be viewed as (1 - % uncertainty) and should be a large number. Most users find an uncertainty specification useful and easy to interpret.

119. **Q. What is the difference between uncertainty and stability?**

A. Uncertainty refers to deviation from an existing standard (known as traceability). The 5440A accuracy is traceable to the National Bureau of Standards (NBS).

Stability need not include uncertainty. Stability refers to shifts occurring during a specified time period. Generally an accurate source implies good stability. The 5440A has a 4 ppm basic uncertainty for a thirty day time period. Therefore the 5440A will not vary more than 4 ppm from NBS standards for 30 days after internal and external calibration has been performed. If a constant output is held for the same 30 day interval, the basic stability specification is 1.8 ppm at 10V.

120. **Q. You say that the basic thirty day uncertainty of the 5440A is 4 ppm. What are the sources of error?**

A. Uncertainties are introduced by the internal reference, the d-a converter, and the precision dc amplifier. The calibration instruments themselves (e.g. Fluke 732A DC Reference Standard and 752A Reference Divider) also add uncertainty. For a complete discussion of this topic see "Calibrator Brings Record Accuracy Even to Production and Repair," *Electronics*, 8 September 1982, pp 121-127.

121. **Q. What is the accuracy specification if internal and external calibration are not performed?**

A. The primary accuracy specification of the 5440A includes daily internal calibration. This process takes less than 5 minutes and requires no user interaction. The *5440A Instrument Specifications* (Fluke document A0171) includes data for 30-days, 90-days, 6 months, and 1 year.

122. **Q. What does linearity mean?**

A. An important feature of a calibrator is its linearity specification. To determine linearity, output voltages are compared to a straight line output function (to remove offset and gain errors). If all output voltages could be represented as a point on the straight line then the calibrator would be perfectly linear. A linearity specification of one part per million (1 ppm) means that the output can deviate as much as 1 ppm from the line. A floor specification allows for deviations that occur at very low levels.

123. **Q. The 5440A has a specification called CMRR. What does this mean?**

A. CMRR stands for common mode rejection ratio. Often an emf exists between chassis and OUTPUT LO (or the user may wish to create one). CMRR specifies how much the output will change due to the common mode voltage. For example, a CMRR of 140 dB represents an attenuation of ten million (i.e. a 10V input between chassis and OUTPUT LO would change the output 1 ppm). For best CMRR, connect the GUARD to OUTPUT LO. This is the normal power-up/reset condition.

124. **Q. What does settling time mean?**

A. When the 5440A output voltage is changed, the output voltage does not reach its final voltage instantly. Settling time indicates how long it takes the output to reach a specified tolerance level.

125. **Q. Most calibrators require a ±1°C environment. Is this true for the 5440A?**

A. No, the 5440A contains ovens which house critical temperature sensitive circuitry. Full rated accuracy is obtained over a ±5°C range from the caibration temperature.

126. **Q. What is the output impedance of the 5440A?**

A. The output impedance for the 0.2 volt range is 495 ohms and 450 ohms for the 2 volt range (±1%). The output impedance for all other ranges is less than 0.5 milliohms.

The 732A DC Reference Standard

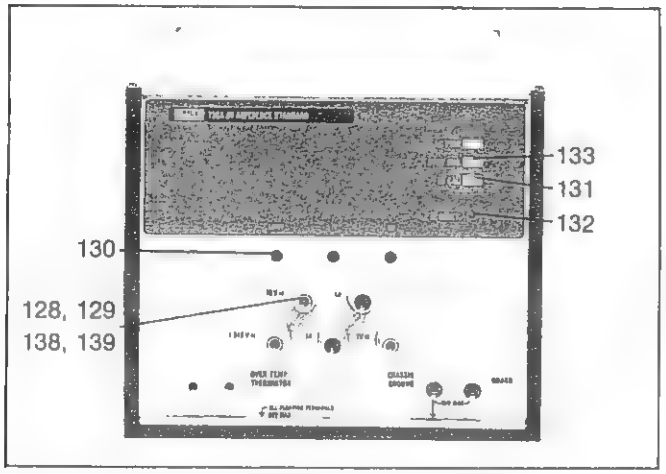


Figure 7: 732A DC Reference Standard

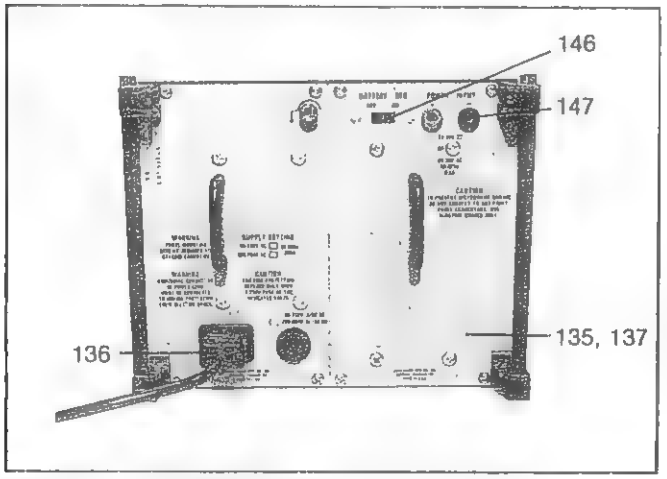


Figure 8: 732A Rear Panel

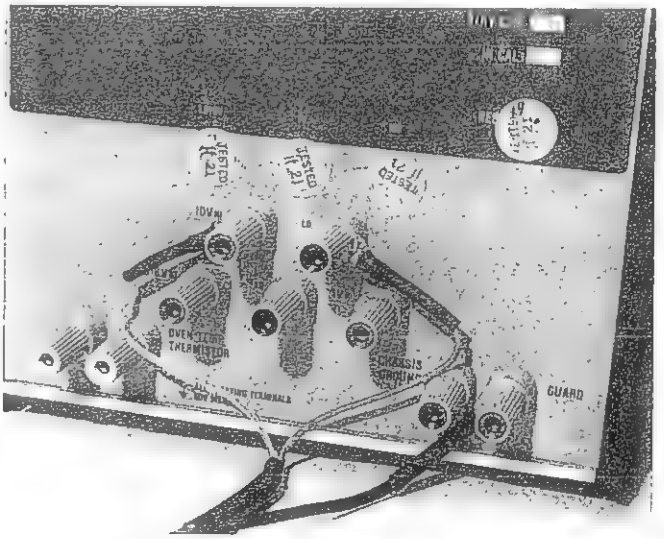
127. **Q. What advantages can I expect from the 732A DC Reference Standard?**

A. The 732A is a solid state DC reference standard which has significant advantages over saturated standard cells. It is stable enough (0.5 ppm stability per month) to substitute directly for a bank of standard cells while its physical and electrical ruggedness make it far easier to use. The use of a 10 volt output in place of the 1.018 volt standard cell output minimizes effects of thermal EMFs and noise. The 732A is shock resistant and operates within an 18°C to 28°C temperature range. The output of the 732A can be loaded, or even shorted, with no damage.

Operation

128. **Q. How do I access the reference voltages of the 732A?**

A. There are five output terminals on the front panel of the instrument. The two top terminals provide the 10V reference. 1V and 1.018V levels are available from the lower three terminals (they share a common LO). The instrument is active when AC power is connected or the batteries are charged.



129. **Q. The 732A has only two-wire output terminals. Does this mean it can't be loaded?**

A. No, the 732A output impedance is less than 5 milliohms on the 10 volt output. Therefore loading effects are minimized. The 1 volt and 1.018 volt outputs, however, have output impedances of approximately 1000 ohms and effects of loading must be considered.

130. **Q. Can I adjust the output of the 732A?**

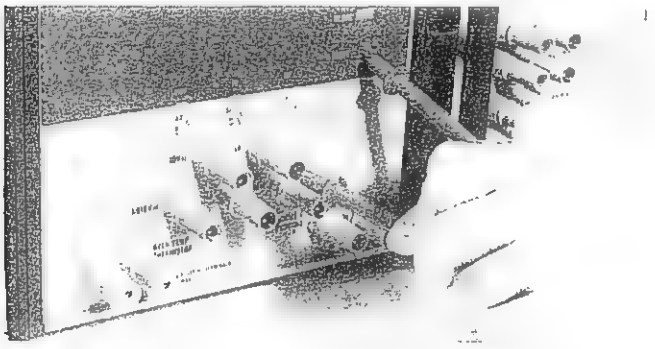
A. Yes, each output of the 732A output can be individually adjusted. For example, the 10 volt output can be adjusted over a ±50 μV (5 ppm) range with a resolution of less than 0.05 ppm.

131. **Q. How can I be certain that the 732A has not lost power?**

A. The IN CAL light on the front panel of the 732A remains lit as long as power is continuously supplied to the instrument. If the light is off, then the unit has lost power since it was calibrated.

132. **Q. How can I reset the IN CAL light?**

A. To reset the IN CAL light, short the RESET connection to the 10V LO terminal with power applied.



133. **Q. What does the BTRY CHG light indicate?**

A. The internal batteries are charging via AC power whenever the BTRY CHG light is on.

134. **Q. How long will the 732A operate on battery power?**

A. The internal batteries in the 732A will last for approximately twelve (12) hours.

135. **Q. Can I rely on the unit if the battery is removed?**

A. Yes, the 732A operates on either battery OR line power. If, for some reason, the battery pack must be removed, the unit will operate on line power. Also, if the power supply is removed, the battery continues to supply power.

136. **Q. Will unstable line voltages affect the 732A?**

A. The 10 volt output changes less than 0.05 ppm with a 10% change in line voltage.

137. **Q. Do the batteries automatically take over when line power is removed from the 732A?**

A. Yes, if power fails or the unit is unplugged, the batteries automatically maintain the 732A (however, the battery switch on the rear of the instrument must be in the "ON" position).

138. **Q. Will I damage the unit if 1000 volts is accidently applied to the 732A output terminals:**

A. The 732A has internal circuitry to protect from such accidental connections to high voltage. The 732A can withstand 1000 volts as long as the external current into the 732A does not exceed 30 mA.

139. **Q. What happens to the unit if the output terminals are shorted?**

A. The 732A contains internal circuitry which protects against accidental shorting. The 732A may be shorted indefinitely without damaging the unit, however the user should wait for at least one (1) minute after the short has been removed before using the standard.

140. **Q. Can I measure the temperature changes of the 732A reference oven?**

A. Yes, the OVEN TEMP THERMISTOR terminals on the front panel allow monitoring the temperature of the oven. Changes in thermistor value indicate changes in oven temperature.

Calibration

141. **Q. How do I calibrate a 732A?**

A. The 732A can be calibrated by direct comparison to another 732A, by comparison to a bank of nine standard cells or by sending the unit to a calibration facility such as the National Bureau of Standards or a Fluke Service Center.

142. **Q. What instruments do I need to calibrate the 732A?**

A. Besides the 732A or bank of standard cells the metrologist requires a variable reference divider (such as the Fluke 720A Kelvin Varley Divider) and a null detector (e.g. the Fluke 845A) for comparison.

143. **Q. When should the 732A be calibrated?**

A. The calibration interval depends on uncertainty requirements and application. For example, if you require a 1 ppm transfer uncertainty relative to standards then you should check your 732A at least once every month and track 732A performance. If greater accuracy is desired, you can perform a characterization of the 732A versus time. Calibration should also be checked if the 732A has lost power and the IN CAL light is out.

144. **Q. Does the stability of the 732A improve with time?**

A. Evidence indicates that 732A performance improves with time. The exact improvement for an individual unit can be measured and future performance extrapolated.

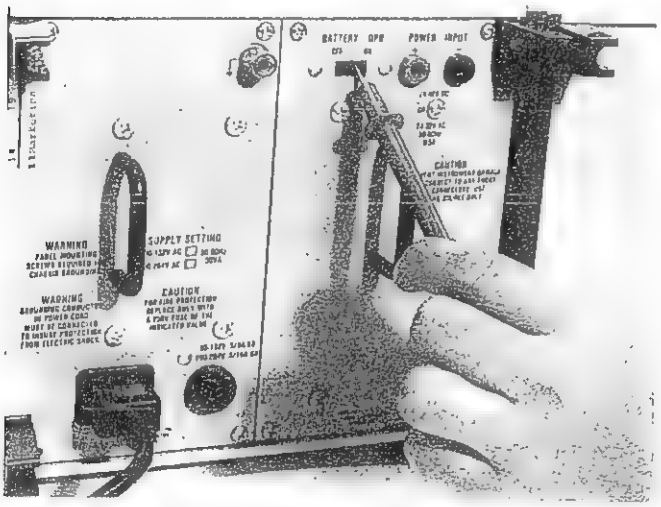
Shipping

145. **Q. How do I ship the 732A (for calibration, maintenance, etc.)?**

A. The 732A Transit Case protects the instrument during shipment. If this case is not available, contact your nearest Fluke Service Center for proper packing and shipping instructions.

146. **Q. Can I turn off the batteries when the unit is shipped?**

A. The instrument contains a battery switch, however a permanent shift in the output voltage may result from removing reference power. Calibration must be performed following loss of power.



147. **Q. Can I supply auxiliary power during shipment?**

A. Yes, power input terminals on the rear of the instrument accept 24V-40V dc and 24V-30V ac (50 Hz-60 Hz).

752A Reference Divider

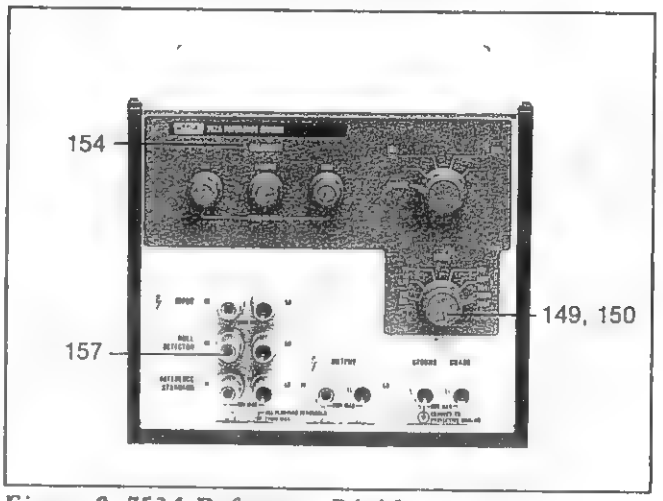


Figure 9: 752A Reference Divider

Operation

148. **Q. Does the 752A require power?**

A. The 752A is a completely passive device, no power is required.

149. **Q. Why is the 752A so easy to use?**

A. All of the switching for operation and calibration is built into the instrument. Therefore the user simply connects the instrument and selects the desired function from the front panel without changing external connections.

150. **Q. Why does the MODE switch have positions for 0.1V to 1000V?**

A. The 752A can be used with the 732A DC Reference Standard to calibrate the Fluke 5440A Direct Voltage Calibrator. The special MODE switch positions allow the user to calibrate each of the six ranges of the 5440A.

151. **Q. Are there environmental restrictions on the use of the 752A?**

A. Yes, changes in ambient conditions can influence the performance of the instrument. For optimum results, the ambient temperature must not vary more than ±1°C from the temperature at which the unit was calibrated. Normally the user calibrates the instrument just prior to use. Humidity should be less than 75% R.H.

Use of the 752A with the 5440A

152. **Q. Do I need special cables to connect the 752A to the 5440A?**

A. Yes, for best results use Fluke Low Thermal EMF Cables (5440A-7002). If these cables are not available use shielded, twisted pair copper wire with low thermal lugs or connectors (preferrably made from Tellurium-Copper).

153. **Q. Must I worry about how I connect cables?**

A. Yes, cable connections must consider the effects of noise and possible ground loops. The proper connecting methods are fully documented in the instruction manual.

154. **Q. What happens if I accidently apply 1000 volts to the 752A? Will I damage the unit?**

A. Yes, high voltages on some terminals may damage the instrument. In the CALIBRATE mode, the input terminals are protected. However, if the voltage is applied to the NULL DETECTOR terminals, severe damage can result. A maximum of 200 volts can be applied to the 10:1 divider. Higher voltages can cause damage or permanent changes in the resistors. The design of the 100:1 divider allows application of up to 1100 volts at the input terminals. High voltage on the output terminals can cause severe damage.

155. **Q. Is the 752A usable only in the calibration of the 5440A?**

A. No, the 752A functions as a stand alone 10:1 and 100:1 divider. For example, the 752A, a null detector, a 10 volt reference, and a Fluke 720A Kelvin Varley Divider can calibrate voltages between 10 and 1000 volts. The unit under test connects to the 752A while the 10 volt reference connects to the 720A. The outputs of the 752A and the 720A are compared with the null detector.

Calibration

156. **Q. What instruments do I need to calibrate the 752A?**

A. A stable 20V source and a null detector (e.g. the Fluke 845AR) are the only instruments required.

157. **Q. How long does the calibration process take?**

A. The 752A can be calibrated in about 5 minutes. The process is quite simple (see Service Manual for exact procedure).

158. **Q. How often must I return my 752A for calibration?**

A. If the 752A passes self-calibration it does not require factory calibration. If the resistors demonstrate long term (i.e. one year) drift which front panel adjustments cannot correct, the user can compensate with internal adjustments.

159. **Q. If I do not send the unit in for calibration, how do I guarantee accuracy?**

A. The self-calibration procedure of the 752A ensures its accuracy will meet specifications. The method used is known as the series-parallel calibration technique for dividers with fixed ratios and is accepted by national standards laboratories as state-of-the-art in ratio calibration. For details see the 752A instruction manual.

John Fluke Mfg. Co., Inc.
P.O. Box C9090, Everett, WA 98206
800-426-0361 (toll free) in most of U.S.A.
206-356-5400 from AK, HI, WA
206-356-5500 from other countries

Fluke (Holland) B.V.
P.O. Box 5053, 5004 EB, Tilburg, The Netherlands
Tel. (013) 673973, TELEX 52237
Phone or write for the name of your local Fluke representative.

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